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[1]pompills.com/research [2]These statements have not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure or prevent any disease. [3]46 men with rising PSA after surgery or radiotherapy drank 8oz 100% pomegranate juice daily for two years. [4]45 patients with coronary heart disease and myocardial ischemia drank 8oz 100% pomegranate juice daily for three months.

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WRITTEN QUIETLY. SOMETIMES IT REQUIRES
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ON THE COVER: Embedded with Marine Medium Tiltrotor Squadron 261, Ed Darack photographed an MV-22 Osprey as it rocketed last December across the rose-colored sands of Afghanistan.

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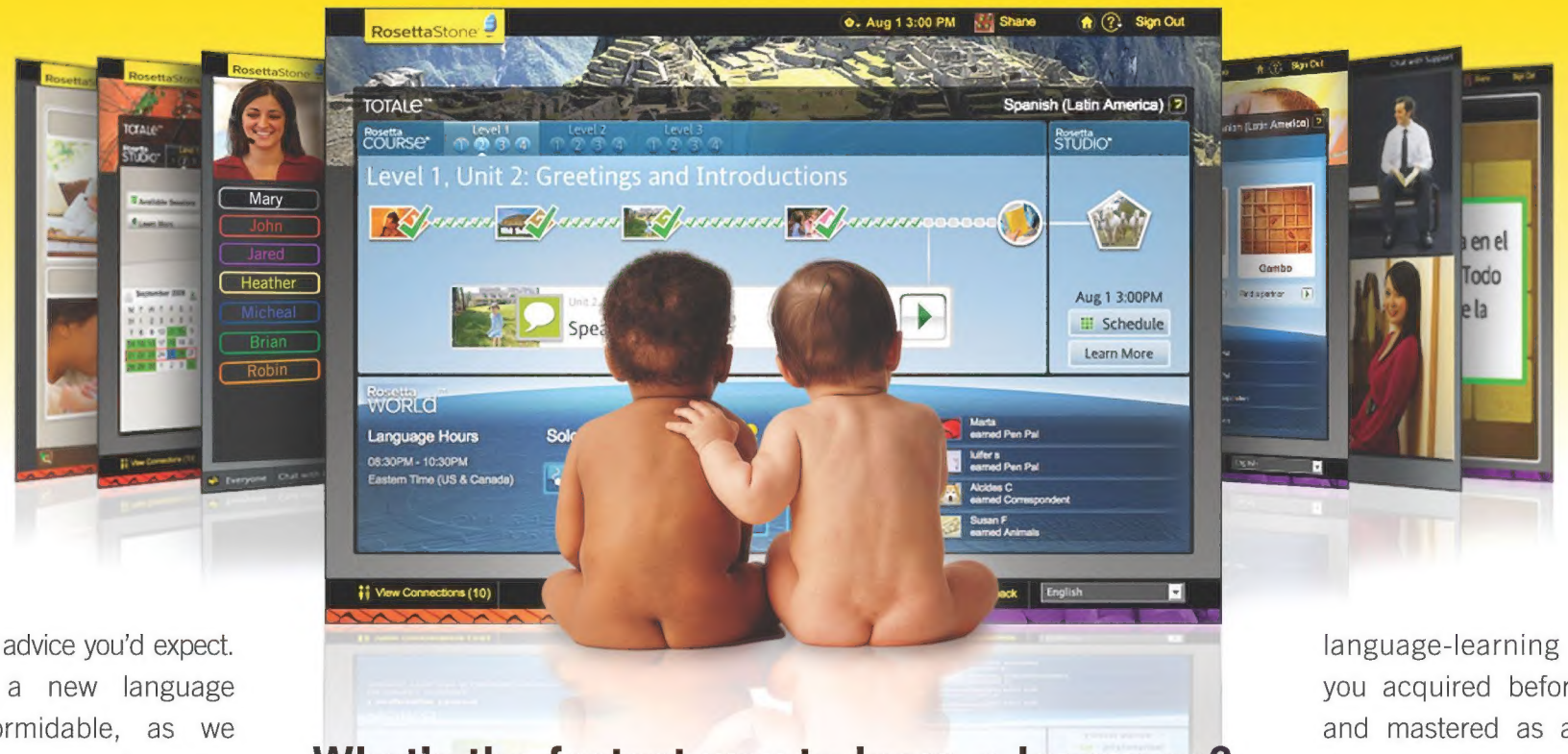
On the Web Site www.airspacemag.com
See video of MV-22 Ospreys in Afghanistan, read the story of "The One-Dollar Pietenpol," and download our Airshow Spotter's Guide, perfect for collecting autographs from your favorite performers. **Also:** Use our interactive schedule to find the airshows nearest you.



What's the fastest way to learn a language?

ACT LIKE A BABY.

It's not the advice you'd expect. Learning a new language seems formidable, as we recall from years of combat with grammar and translations in school. Yet infants begin at birth. They communicate at eighteen months and speak the language fluently before they go to school. And they never battle translations or grammar explanations along the way. Born into a veritable language jamboree, children figure out language purely from the sounds, objects and interactions around them. Their senses fire up neural circuits that send the stimuli to different language areas in the brain. Meanings fuse to words. Words string into structures. And language erupts.

Three characteristics of the child's language-learning process are crucial for success:

First, and most importantly, a child's natural language-learning ability emerges only in a speech-soaked, immersion environment free of translations and explanations of grammar. Second, a child's language learning is dramatically accelerated by constant feedback from family and friends. Positive correction and persistent reinforcement nurture the child's language and language skills into full communicative expression. Third, children learn through play, whether it's the arm-waving balancing act that announces their first step or the spluttering preamble to their first words. All the conversational chatter skittering through young children's play with parents and playmates — "...what's this..." "...clap, clap your hands..." "...my ball..."— helps children develop language skills that connect them to the world.

Adults possess this same powerful language-learning ability that orchestrated our language success as children.

Sadly, our clashes with vocabulary drills and grammar explanations force us to conclude it's hopeless. We simply don't have "the language-learning gene." At Rosetta Stone, we know otherwise. You can recover your native language-learning ability as an adult by prompting your brain to learn language the way it's wired to learn language: by complete immersion. Our award-winning, computer-based method does just that. Dynamic Immersion® unlocks the innate language-learning ability you acquired before birth and mastered as a child. By recreating the immersion context in which you learned your first language, you understand, speak, read and write your new language with confidence and accuracy from the beginning — without translations and explanations. At every step and in every skill, you receive instant, actionable feedback, including speech recognition and analysis technologies that prepare you for everyday conversations. And Adaptive Recall® brings back material just when you need it to reinforce and perfect your learning.

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Viewport

FROM THE DIRECTOR

All the Sky's a Stage

It's airshow season again—my favorite time of year, when skies all around the country fill with pilots flying maneuvers that seem with every show to grow more intricate and exciting. In North America, airshows entertain about 18 million spectators a year, thrilling fans, supporting aviation, and earning revenue for local communities. You'll find a guide to 2010 shows at *airspacemag.com* and highlights of the season's offerings on page 20.

The National Air and Space Museum has a stellar collection of airshow and competition aerobatic aircraft that have been flown by the best in the business. At the Museum on the National Mall, the Extra 260 in which Patty Wagstaff became the first woman to win the title of National Aerobatic Champion is suspended as if she were flying her inverted ribbon-cut maneuver.

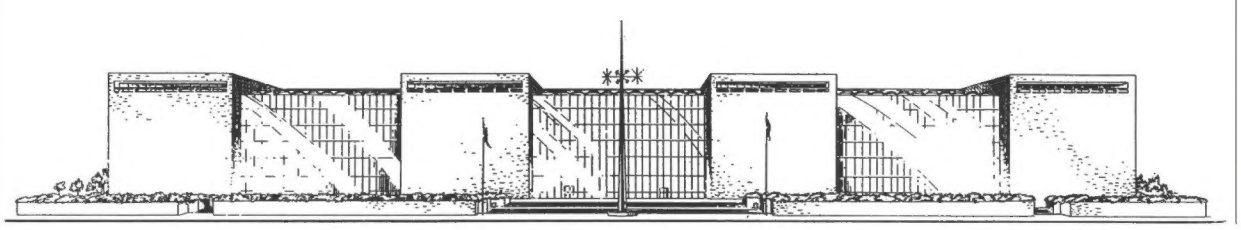
Most of our aerobatic aircraft are on display at the Museum's Steven F. Udvar-Hazy Center in Virginia, where we have installed them so they appear to continue flying their routines. When you enter the Museum, look up, and the first airplane you'll see is the Pitts Special "Little Stinker," a snappy red and white biplane made famous in the 1950s by aerobatic champion Betty Skelton. Skelton often flew it just as it is displayed—inverted.

Walk along a mezzanine and pass by Al Williams' two orange Gulfhawks, used to promote military aviation. Bevo Howard's Bücker Jungmeister makes an inverted pass by Woody Edmondson's Monocoupe 110, and, high above, Art Scholl's de Havilland Chipmunk is in a steep bank around Leo Loudenslager's Laser 200, which is shooting up in a vertical climb. Nearby, Suzanne Asbury-Oliver's Pepsi Skywriter sets up for a pass over Gerry Molidor's Sukhoi Su-26M. On the hangar floor at the Aerobatic Exhibit Station, you can learn more about the pilots, aircraft, and art and science of precision flying.

One of the most unusual aircraft in this world of highly modified showplanes is the distinctly unmodified North American Rockwell Shrike Commander 500S, an executive business aircraft flown by the legendary Robert A. "Bob" Hoover (see "Simply the Best," p. 28). Hoover, who will be the Charles A. Lindbergh Lecturer at the Museum on May 18, was a North American Aviation test pilot who flew sophisticated military designs to their limits and performed in many types of aircraft at more than 2,500 civilian and military airshows. He flew the Shrike Commander in a breathtakingly smooth aerobatic program. No less an expert pilot than the late Jimmy Doolittle called Hoover "the greatest stick and rudder man who ever lived." For proof, watch a YouTube video (search "Hoover" and "tea") of Hoover expertly rolling his Shrike while pouring iced tea into a glass and not spilling a drop.

In 2003, Hoover performed his last "roll to airshow center" finale—in this case taxiing the Shrike into the north end of the Udvar-Hazy Center and into history.

J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



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Letters

WRITE TO US

One Line, Two Sides

You missed another hazard of no-fly zones ("Don't Cross That Line," Feb./Mar. 2010). A friend and avid recreational pilot, Dan Eberhardt, took off from one of the small airports in Maryland you mentioned. He apparently strayed into such a zone, and air traffic control ordered him to land immediately. On approach to the airport, he stalled, crashed, and burned; both Dan and his passenger were killed. Dan had years of experience and was considered a good and safe pilot. Many of us believe he became flustered by the unexpected command to land and made a fatal mistake.

Robert L. Wells
Aiken, South Carolina

After the 9/11 terrorist attacks, when the Flight-Restricted Zone was placed over Washington, D.C., every time an aircraft penetrated the inner ring, high-level government officials had to be evacuated to underground bunkers. Finally, President George W. Bush brought in experts. The U.S. Customs was the only agency with experience in detecting and intercepting the type of aircraft violating the FRZ.

In the beginning of our deployment to Reagan National Airport, if it was a weekend and the weather was good, I would sometimes intercept three aircraft per hour, all day long. Within weeks, intrusions went down to one per month, then to zero. We may have appeared to come on strong to the pilot who violated restricted airspace because he failed to use a current chart, plan his flight, check Notams (Notice to Airman), or properly navigate, but word got out fast. Straying where you didn't belong would get you a closeup formation flight with an armed Blackhawk helicopter and an interrogation from Secret Service agents.

Herb Galliart
El Paso, Texas

Adventures in Deadsticking

In his letter (Feb./Mar. 2010), Doug Loeffler describes an F-8 with an engine flameout occurring aft of a carrier, and says the pilot flew the aircraft "two-thirds of a mile" to land on the ship. As an experienced landing signal officer and F-8 pilot, I assure you that an engine failure at two-thirds of a mile from a carrier would result in a very wet landing, not a trap on the no. 1 wire.

Nels Tanner
via e-mail

Editors' reply: The book from which Mr. Loeffler got the story, Feet Wet *by Paul*

Don't Cross That Line

WOULD A FIGHTER PILOT SHOOT DOWN A PRIVATE AIRPLANE? BY CRAIG MELLOW

THE EIGHT-SEAT recreational airplane, a single-engine Gippsland Airvan, is cruising peacefully over southern Maryland on a hazy June afternoon, pilot and passengers enjoying the view from 4,000 feet, where the Nanticoke River runs into the swamplands at the edge of the Chesapeake Bay. Suddenly—*whoosh*! A trademark shape most of us encounter only in the movies or at airshows darts underneath the 100-knot pleasure craft, then carves a semi-circle in the sky in front of it. A voice crackles in the pilot's headset: "This is a United States Air Force armed F-16. You are in violation of restricted airspace. Do you require any assistance?"

No response from the Airvan. A minute or two later, the fighter is back, aiming for a more dramatic impression. It executes the "head butt," soaring up vertically within 500 feet of the intruder's nose. The voice in the earphones sounds less helpful this time: "This is a United States Air Force armed F-16. You have been intercepted. Please acknowledge or rock your wings."

The jet and an unseen wingman have scrambled from Andrews Air Force Base, just east of Washington, D.C. But their controllers sit 400 miles north, outside the faded Erie Canal town of Rome, New York, amid a forest of glowing monitors at the headquarters of the Eastern Air Defense Sector (EADS). Yellow blips track every aircraft aloft east of the Mississippi River, several thousand on a typical weekday afternoon like this.

A general aviation airplane without a flight plan, chugging into restricted airspace, does not take long to stick out from the herd. If the Airvan continues to ignore the fighters in its face, EADS will pass an alert up a chain of command, where unspecified persons will have to decide what to do about it, perhaps within minutes, if the off-course pilot swings west toward the nation's capital.

This particular interception turns out to be a dress rehearsal. The Airvan's pilot and copilot are Bill Parris and Michael Regen, two Civil Air Patrol volunteers on a day off from their real jobs, as radio station owner and restaurant supply wholesaler. The routine is choreographed in advance with the Andrews top guns. "Nice work, braves," Parris compliments the F-16 pilots as the passenger airplane peels off toward its home hangar, at Martin State Airport near Baltimore.

This was practice, but the real thing happens often enough. One of the few detailed studies on the subject, a 2005 Government Accountability Office (GAO) report, found 3,400 violations of restricted airspace, or about three a day, in the 39 months following the September 11, 2001 terrorist attacks, which rewrote the rules of U.S. aviation. About 88 percent of the offenders were general aviation pilots, and seven percent were military. The most common reasons for infractions were pilots altering flight plans to avoid bad weather, or not keeping up to date on the shifts and expansions of the government's no-fly zones. The zones can change with little warning, as when the president travels. Nearly half the violations—45 percent—tallied by the GAO were in the Washington, D.C. area.

Most violators, of course, respond to a radio warning from Federal Aviation Administration controllers, and if not to that, then to the bright red and green lights used to flood the cockpit of intruders in the vicinity of Washington, and if not that, then to the Coast Guard Dolphin helicopters that sometimes precede the jet fighters. All the same, military aircraft have engaged interlopers "hundreds of times" over American skies since 9/11, says David 1 Agostino, the GAO's director of Defense Capabilities and Management. And defenders cite at least three cases last year alone when they feared they would be ordered to apply the ultimate sanction: annihilating a general aviation aircraft to stop it from committing a presumed terrorist act.

On April 6, 2009, what turned out to be a mentally disturbed young Canadian pilot entered U.S. airspace over Lake Superior without warning, and led Air National Guard F-16s on a five-hour chase over four states before finally landing on a country road in Missouri. Minnesota Air National Guard pilots were the first to intercept the Cessna 172 near Michigan's Upper Peninsula. National Guard units from Wisconsin and Louisiana took over as the pilot continued south without responding to the military jets.

"Failing to raise the off course Cessna 172 on the radio, the F-16s improvised various stunts to get the pilot's attention: firing flares in front of the renegade aircraft and flashing their landing lights," recalls Colonel Joe Brandenmuehl, commander of the Wisconsin Air National Guard wing that handled most of the pursuit. When the Cessna came within five miles of downtown Madison, the governor, on the recommendation of the Wisconsin homeland security advisor, ordered the state capitol building evacuated.

The Missouri state troopers who arrested Adam Leon reported he was trying to commit suicide. "If he had turned toward Chicago, he would have gotten his wish," says Gary Miller of the Federal Aviation Administration's Office of Tactical Operations Security, who monitored the slow chase. "That's the closest we've ever come to shooting down somebody on my watch."

Just 18 days later, Maine retiree William Wales, flying down to see his daughter in North Carolina, strayed over Washington, D.C.'s restricted zone. Though repeatedly hailed on emergency frequencies by F-16s, he failed to respond, prompting a lockdown at the White House, preparations to evacuate the Capitol, and frayed nerves at EADS, whose staff flagged the incident to the North American Aerospace Defense Command (NORAD) in Colorado and braced for an order to fire. "Everything looked to be going against this man for a

A pair of F-16s from the Washington, D.C. Air National Guard patrol over the capitol, which has more no-fly zones (opposite) than any other U.S. city. Pilot William Wales (below) learned this the hard way last April when he accidentally flew into restricted airspace.

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Letters

Gillcrist, does not specify how far the pilot was from the carrier when his engine lost power.

I probably hold the record for the most World War II military aircraft landed without the help of the engine ("Deadstick Landings," Dec. 2009/Jan. 2010).

Royal Canadian Air Force: One Blenheim Mk V and one Beaufighter Mk 2 (both totalled).

U.S. Navy: Two double-deadstick days: FM-2 and F4U-4 (no damage to any).

One FM-2 in a cotton field near Coolidge, Arizona (totalled).

Lt. Cdr. George E. Sutton
U.S. Navy Reserve (ret.)
Poland, Ohio

Quietly Making History

I was pleasantly surprised to see a picture of Perry Young ("The Other Harlem," Feb./Mar. 2010). I first met Perry when he was hired as a copilot at New York Airways in 1956 or '57 to fly our S-58 helicopters. A loyal employee, Perry flew both helicopters and fixed-wing aircraft, mostly as a captain, until NYA ceased operating in 1979. I believe he was the first black pilot hired by a scheduled air carrier and the first black pilot to belong to the Air Line Pilots Association.

At the time we heard a lot of snide remarks from other airline pilots and from some of our own pilots about flying with a black pilot.

Perry kept pretty much to himself, so none of us realized that he had been flying longer than any other New York Airways pilots, who were all World War II-vintage.

John B. Conley
Greenport, New York

SI-91-15487-P

Perry Young, with his mother (left) and Willa Brown, at Harlem Airport in 1941.

Corrections

Feb./Mar. 2010 "Bronco's Tale": The photograph on the top of p. 67 shows two Broncos, not one.

"Our Favorite Martians": Mars' gravity, not its mass, is 38 percent that of Earth's; its mass is about 10 percent that of Earth's.

Dec. 2009/Jan. 2010 "Deadstick Landings": The Piper Seneca that ran out of fuel was flown by the owner, James Rich, not Alan Clark.

"Thanks for the Memories": The photograph on the top of p. 23 shows Bob Hope and Jill St. John sitting on an engine, not a fuselage. (The aircraft is almost certainly a KC-135 Stratotanker.)

Aug. 2009: "From Pilot to President": Dave Rahm, who was killed while flying with the Royal Jordanian Falcons, was American, not Canadian.

WRITE TO US at Letters, *Air & Space/Smithsonian,* MRC 513, P.O. Box 37012, Washington, DC 20013. Please type or print clearly. You must include your full address and daytime phone number.

e-mail: *editors@si.edu*. All e-mails must include your full name, mailing address, and daytime phone number.

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From the Asteroid Belt to the Courtroom

Unlike Humpty Dumpty, Lorton meteorite fragments can be reassembled (left). Thousands saw it streak in (inset, top).

SHORTLY AFTER a fist-size meteorite plowed through the roof of a medical building in Lorton, Virginia, on January 18, the physicians who rent the office in which it landed—after heaving a sigh of relief that they were spared a close encounter of the concussive kind—gathered up the pieces and gave them to the Smithsonian's National Museum of Natural History in Washington, D.C.

The Lorton meteorite, a 4.5 billion-year-old stony chondrite similar to the majority of meteorites found on Earth, earned bonus points because thousands of people had seen it streaking through the sky at dusk, making it "a witnessed fall"—and in the nation's capital to boot. Meteorite hunters descended on Lorton to search what they call the "strewnfield," an area where more pieces might turn up (none did).

Because the doctors could likely have gotten, say, $50,000 on the open market, says meteorite hunter Robert Haag of Tucson, Arizona, the museum offered them $5,000 for their find, which the doctors said they would donate to the Haiti earthquake relief effort. The museum planned to put the half-pound chondrite, which the doctors call "the people's rock," on prominent display.

That's when the fight started.

The owners of the medical building notified their tenants that they were heading to the museum to reclaim the meteorite, which, they said, rightfully belongs to them. Both parties immediately lawyered up. The museum said the stone would stay put until a court issues a verdict.

The Museum of Natural History has the largest trove of meteorites—some 15,500 of the 27,000 or so in collections worldwide—so why does it need another one? Particularly another plain-vanilla chondrite, the same flavor as nearly all of its meteorites? "It is untouched by terrestrial weathering and provides us with pristine materials to study," says Linda Welzenbach, meteorite collection manager, adding, "We hope that donations of new falls will encourage others to make these rare objects available to educate the public."

Does she still get chills from holding an ancient space rock in her palm? "YES!!!" she wrote in an e-mail. "I don't get to do it enough, to be honest."

PATRICIA TRENNER

BOTTOM & MIDDLE: CHIP CLARK/COURTESY SMITHSONIAN'S NATIONAL MUSEUM OF NATURAL HISTORY; TOP: MR./MRS. TOM CINELLI

UPDATE

Price Rollback!

NASA HAS REDUCED THE PRICE of preparing an orbiter for display and transport to a U.S. airport from $42 million to $28.8 million ("Shuttles for Sale," Feb./Mar. 2010). In a press release last January 15, the agency noted, "NASA has updated the requirements and tasks needed to make each orbiter safe for disposition...[and] will not ask recipients to provide the funds for this activity." *Endeavour* and *Atlantis* will be ready for transfer by July 2011 (*Discovery* has already been designated to go to the National Air and Space Museum).

Honoring Vanley Johnson

FOR THE PAST half-century, racers competing on Utah's Bonneville Salt Flats to set land-speed records have been paying their respects at a mysterious white concrete cross, just off what is now Interstate 80, that bears only the name "Vanley."

Over the years, small pieces of airplane wreckage have worked their way up from the soft earth, and passersby arranged them in a pile around the marker. Visitors place flowers around what they have assumed is the gravesite of a military aviator flying out of the nearby Wendover, Utah, airfield, closed now but once best known for training the crew of the B-29 bomber *Enola Gay*.

Last August, a discovery at the site confirmed the story. A pair of dog tags—fused, perhaps because they were buried for 55 years—surfaced near the marker. Armed with the pilot's full name, members of the Southern California Timing Association, which sanctions racing at Bonneville, were able to get to the bottom of the story.

A pair of fused dog tags solved the mystery of the white concrete cross at Utah's Bonneville Salt Flats.

Captain Vanley T. Johnson, a veteran of World War II and the Korean War, was killed in 1954 during an air-to-air gunnery mission when he was overcome by smoke in his North American F-86F and crashed near Wendover. The impact was so fierce that neither the airplane nor the body was recovered, and the huge crash crater was bulldozed over. A year later, Johnson's parents and older brother, Ralph, marked the site with the homemade cross.

In December, SCTA president Roy Creel made a pilgrimage to Rineyville, Kentucky, to deliver the dog tags. When Creel arrived at the home of Johnson's younger brother, Alan, the house was filled with 50 grateful members of the extended family. "To go 50 years and not hear a thing about the dog tags and then to get them back...a cold chill came over us," Alan Johnson said. "It meant the world to us."

This fall, the Johnson family plans a pilgrimage of its own—back to Wendover and the site of Vanley's memorial.

PRESTON LERNER

PARAJUMPING

"Release the Hounds!"

DOGS HAVE PARTICIPATED in parachute operations since World War II, when Allied paratroopers experimented with bringing dogs on special missions, but earning parachute wings nowadays requires rigorous training for both dogs and handlers. Dogs' acute sense of smell and desire to serve make them invaluable for emergency search-and-rescue missions, and they are being used in growing numbers to track enemies and detect improvised explosive devices in Iraq and Afghanistan. For military applications, says T.K. Donle, technical director at Complete Parachute Solutions in DeLand, Florida, parachuting is much stealthier than overland travel through hostile territory. "In the special ops community, this usually means a parachute insertion at night from high altitudes."

Dogs undergo behavioral evaluations to ensure they're good candidates for the demands of jumping, and handlers make practice jumps with canine mannequins before jumping with their dogs, who are fitted with customized harnesses, insulated pouches for warmth, and oxygen masks for high-altitude jumps. K9 Storm, based in Canada, offers parachute-ready harnesses with bulletproof panels. A $20,000 system includes a wireless camera, speakers, and microphone so the handler sees what the dog sees and issues commands through the audio system.

Mike Forsythe, with his Beauceron, Cara, strapped on tight, dives from a Shorts S.C.7 Skyvan.

Mike Forsythe and his Beauceron, Cara, hold the record for the world's highest and fastest canine parachute deployment: 30,100 feet and 205 mph, set in 2004.

BENJAMIN ROMAN

TOP: GREG AND JOANN CARLSON; BOTTOM: CPS

A Negligible Space Prize

ORGANIZER PAUL DEAR, an English microbiologist, bills it as "a challenge to launch an impossibly small satellite into orbit on a ludicrously small budget, for a pitifully small cash prize." The N-Prize will award £9,999.99—about $15,400—to an amateur team that launches 9.99 to 19.99 grams into orbit for less than £999.99 and proves that the payload makes at least nine orbits. Deadline: September 2011

Impossible? Probably, says space systems engineering professor Karl Siebold of Embry-Riddle Aeronautical University in Arizona. "Classical orbital mechanics pretty much tell you that you either have a continuous thrust all the way up there," which would require a prohibitively expensive attitude control system, "or you have to have two distinct delta-V maneuvers." That's one blast to clear the atmosphere, and one to kick the payload sideways into orbit, for a total velocity of five miles per second. "That is huge."

Just the challenge of getting out of the atmosphere proved insurmountable to competitors for the arguably less ambitious Cheap Access to Space prize. That contest, for sending a 4.4-pound payload to an altitude of 124 miles, closed in 2000 with the $250,000 purse unclaimed.

Undaunted, 22 competitors from around the world are making a run for the N-Prize, including Charles Pooley, American commercial-space activist. His team, Microlaunchers, proposes modifying a cell phone transmitter to fly on a three-stage liquid-fuel rocket with beverage cans as propellant tanks.

Other schemes include New Zealand-based Te Anahera Tere's plan to fire a multi-stage rocket from "a very large cannon"; Cambridge University (England) Spaceflight's plan for a balloon rocket launch; and U.K. electronics engineer Peter Jones' approach calling for a novel aerospike engine.

Regardless of whether a team wins the prize ("Don't tell my wife I'm putting up the money," says Dear), it has already sparked a lot of creative thought about the problem of reaching space on the cheap. And that's exactly the point. "I'd be very surprised if we don't see some real innovation and commercial opportunities coming out of this," says Dear.

MICHAEL BELFIORE

A Not-So-Hot Market?

WHEN SPACE SHUTTLE *Discovery* touches down after the space shuttle program's final mission in September, some shuttle enthusiasts may be poised at computer monitors, looking at toys and collectibles from a historic space program and ready to click either the "buy" or "sell" button—depending on the collector.

Terry Kovel, publisher of Kovels' price guides for antiques and collectibles, says space toys are big business. "Ninety-nine percent of us will never [go into space]," she says. "It's the only way we can enjoy it."

But Leonard Lee, publisher of *Lee's Toy Review* magazine, isn't so sure shuttle-theme toys will capture the wide collector audience that has gone after Mattel's Hot Wheels or *Star Wars* figurines. "All collectibles have to be based on something that was intrinsic to a point in [the collector's] life," he says. "It's something that affected you, and you go back for it."

There are plenty of shuttle items sitting on at least a few collectors' shelves. Companies like Revell, in Elk Grove Village, Illinois, have been re-

Nostalgia in a box: Model kits may see demand when the shuttle program ends.

leasing shuttle model kits for decades, in part because "there are no fees," says Joyce Collier, a Revell sales and marketing official. The shuttle's image is government property and fair game for anyone wanting to base a toy on it.

The most likely collectors are adults who were impressionable children in 1981, when the shuttle first flew. But the impact of the shuttle program's end "will probably be less than people think," says Alan Lipkin, senior vice president of Regency-Superior Auctions, which holds several space memorabilia auctions a year. "There's a mindset in a lot of people that from the late '50s to the Apollo program was the age of exploration." Shuttle flights to repair satellites or supply the International Space Station don't have the same allure, it seems. Lipkin offers an analogy to an earlier era: "It's not Columbus or Marco Polo," he says. "It's the traders going back and forth across the ocean."

MATT CUNNINGHAM

REVELL

Chris Kraft

FORMER NASA FLIGHT DIRECTOR

AS NASA'S FIRST flight director, Christopher Kraft Jr. worked many breakthrough manned missions. In 1972, he was named director of what would become the Johnson Space Center. He retired in 1982.

Christopher Kraft in July 1965, at his console in a mission operations control room at the Manned Spacecraft Center in Houston during a break in training for the upcoming Gemini 5 mission.

Of the memories you wrote about in* Flight: My Life in Mission Control, *what are your proudest moments?

The first was the flight of Alan Shepard. I was the flight director, and seeing him on the end of a rocket as the first human being in the United States to do that was extremely exciting. John Glenn's flight was certainly wonderful, challenging, and rewarding. Apollo 8, in my mind, changed the course of spaceflight because it was the first time man left the gravitational field of Earth and visited another orbiting body. I'm pleased that the powers that be had the faith to allow NASA to make it happen. Landing on the moon was the culmination of a tremendous effort by the whole United States. Seeing the American flag on the moon was something we had set our minds to, and it was a fantastic day.

Do you advocate a return to the moon?

Dr. [Robert] Gilruth, my predecessor at the Johnson Space Center, and I said the same thing: We won't return to the moon again until it becomes easy to do so. Until we are more directly capable of going back to the moon, maybe we ought to slow the pace and take advantage of the space station and then prepare to return to the moon in a little more rational way.

There's hand-wringing over the gap that will occur after the shuttle stops flying; there wasn't over the gap that would occur after Apollo-Soyuz.

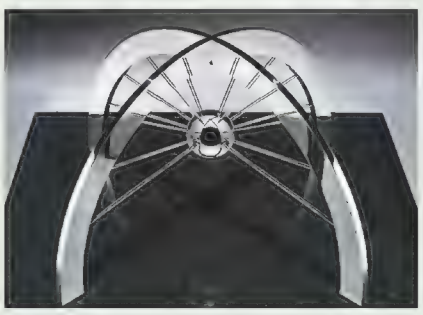
We had a six-year gap between Apollo-Soyuz and the first flight of the shuttle. But we didn't have a space station that will expire, E-X-P-I-R-E, if we don't have something to get up there to use it. We and many other nations have invested over a hundred billion dollars in it. It would be a shame to not take advantage of it if we don't have the capability to go to low Earth orbit with a number of rockets and spacecraft.

Would you buy a ride on a Soyuz rocket to the space station?

I would not. The launch wouldn't be too bad—it's 4 Gs. But coming back at nine Gs [in an abnormal ballistic reentry] is not my cup of tea. It takes well-trained people to enjoy that ride.

How about an orbital flight on the first crewed SpaceX rocket, Falcon 9?

If they can show me by experience that their rockets are safe to fly, I would go. Eventually, I think they can do it. In fact, I want to cheer them on.



The trophy recognizes achievements in the management or execution of scientific or technological projects, a distinguished career in air and space technology, or a significant contribution in chronicling the history of air and space technology.

The National Air and Space Museum Trophy

FOR THEIR PROFESSIONALISM in assuring the safety of the passengers on their disabled airliner, the crew of US Airways Flight 1549 will receive the 2010 National Air and Space Museum Trophy for current achievement. On takeoff from New York's LaGuardia Airport in January 2009, their Airbus A320 struck a flock of birds, resulting in the loss of power from both engines. Captain Chesley B. Sullenberger III and First Officer Jeffrey B. Skiles ditched the aircraft in the Hudson River, and, with the help of flight attendants Sheila Dail, Donna Dent, and Doreen Walsh, evacuated all 150 passengers. (Sullenberger's book *Highest Duty* is reviewed on page 76. To read the *Air & Space* Interview with Sullenberger, go to *airspacemag.com/flight-today/Sullys-Tale.html*.)

The Museum will award the trophy for lifetime achievement to Christopher Columbus Kraft Jr., former director of NASA's Johnson Space Center in Houston, Texas, and Director of Flight Operations during the Apollo program.

On April 28, the winners of this year's National Air and Space Museum Trophy awards will take part in an online conference. Participants can submit questions in advance via e-mail or in real time during the conference. Visit *http://www.nasm.si.edu* for information on how to participate in this free event.

TOP: NASA; BOTTOM: ERIC LONG

A la Cart

Using the "Living and Working in Space" station, Amelia Yonan describes a spacesuit's multiple layers – from its anti-itch lining to an external micro-meteoroid-proof covering.

THE PIG WAS PART OF the flight demonstration.

Perhaps inspired by the old saw "When pigs fly," an educator had assembled a plastic pig, a sheep, a dragonfly, a butterfly, two airplanes, and a boat. They were all perched atop a cart for National Air and Space Museum volunteer Bob Greene to use to introduce a four-year-old visitor to the principles of flight. The Museum's youngest visitors are encouraged to find similarities between airplanes, birds, and insects, and to separate them from, well, the pig. Using other objects at the station, Greene familiarizes adults with the concepts of pitch, yaw, and roll.

Greene has volunteered since 2003 at various Discovery Stations—a series of portable carts that feature hands-on activities related to aviation, space exploration, astronomy, and planetary geology. He's a pilot with more than 3,000 hours flying Bell UH-1H "Huey" helicopters during two tours in Vietnam. Today at the Steven F. Udvar-Hazy Center in Virginia, his cart is parked next to a reproduction of the Wright Model B, but Greene talks easily with a visitor whose father flew a World War II Lockheed P-38J Lightning, much like the one a few feet away.

Education and curatorial staffs develop the stations to help explain the more complicated concepts in an exhibition. "With the Wright brothers exhibit," says Beth Wilson, who coordinates the Discovery Station program on the National Mall, "it's difficult to understand wing warping unless you either have a lot of knowledge about it to begin with, or there's someone there explaining it to you. It's the same thing with our Black Holes Discovery Station. You can read a label about a black hole, but if you have someone there describing it, it really helps." (The objects used to demonstrate this challenging concept? A magnet, glass marbles, and a steel ball.)

Dan Grünberg, a junior at the University of Maryland, has worked at the Museum for almost three years. Today he's staffing the "America by Air" Discovery Station, which accompanies the exhibition of the same name. His cart is covered with models of the aircraft in the exhibition, a passenger window from a Boeing 747, and other bits and pieces that help illustrate the story of commercial flight.

Grünberg points to the Ford 5-AT Tri-Motor hanging from the ceiling at the Museum on the Mall, its corrugated aluminum exterior glinting in the sunlight. "This is one of the first planes to carry people commercially," he tells a group of young visitors. "The plane ride was

Katherine Peterson teaches visitors about airport codes.

LEFT: DANE PENLAND; TOP: MARK AVINO

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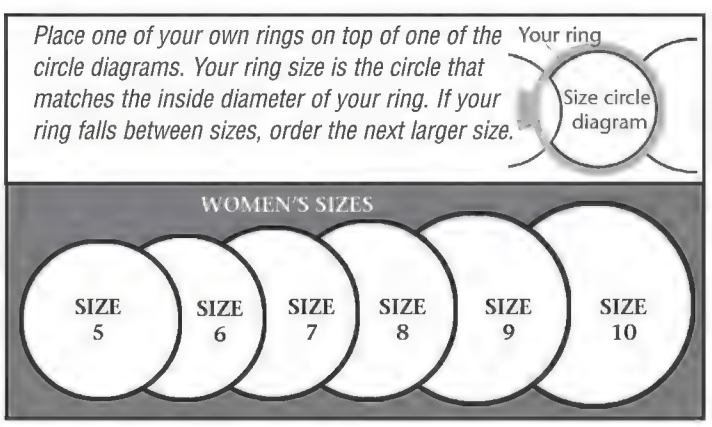

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very bumpy, and the bolts in your seat had to be tightened every once in a while, so your stewardess would carry a wrench in her pocket.

"Now, a lot of people hadn't been on planes before," he continues. "So people wanted to look out the window." Those who didn't have a window seat, he says, would go to the door to look out *that* window. "The problem was, there's no safety on the door," says Grünberg. "You could literally just turn the knob and open it."

The children look at each other, impressed by the thought of a door opening at 5,200 feet.

"So they had to put up a sign," Grünberg tells them, "saying 'It is dangerous to open up the airplane while it's in motion.' You guys think that would be common sense, but believe me, common sense isn't so common."

While the Discovery Stations sometimes include computers and other electronics, they're more likely to feature items from aerospace history: an astronaut's spacesuit, a space shuttle thermal tile, fabric from a vintage aircraft's wing.

"People are curious," says Wilson. "If we can show visitors the real thing and they have the opportunity to touch something and hear the story behind it, it's an added benefit to their visit."

As Bob Greene prepares for the next group of visitors to approach, he says, "It's a tough thing—and I think an important thing—for the Museum to appeal to children. And it's hard sometimes, particularly at Hazy where it's mostly just airplanes. So it takes working one-on-one to get kids to see what's going on. That's what's nice about the Discovery Stations. They really add something to the Museum."

Grünberg remembers one seven-year-old girl, an avid Harry Potter fan, who approached his station wanting help with a secret project. "She wanted to design a broom that flies. She whipped out a drawing with labels everywhere, and she had all of these concepts she wanted to know about. We talked for 15 minutes about her idea." He pauses, remembering the encounter. "You know, maybe she won't design a broom that flies. But she *might* become an engineer."

REBECCA MAKSEL

Visitor Information

Family Days Celebrate "Explore the Universe Day" on April 10 at the Museum on the National Mall. Astronomy will serve as a common theme for visitors to learn how different people and cultures view and talk about the sky. Make your own telescope to bring home for exploring the sky at night. Admission is free; the event runs from 10 a.m. until 3 p.m.

What's Up Receive regular updates on Museum events, read about artifacts, get detailed (and behind-the-scenes) exhibition information, and receive calendar listings, all by subscribing to the National Air and Space Museum's free monthly newsletter, *What's Up*. Sign up at *www.nasm.si.edu*.

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ARTIFACTS

Small Wonder

THE NIFTY LITTLE HM.14 Pou du Ciel (literally Sky Louse, but known in English as the Flying Flea) was the brainchild of amateur designer Henri Mignet, who helped spark the home-built movement in France and Britain during the 1930s. Unfortunately, a series of accidents led government officials in both countries to ban the small aircraft. (Mignet later modified the design, but the public had lost interest.) In 1935, American entrepreneur Powell Crosley Jr. stumbled upon Mignet's plans and financed the first U.S.-built Flea. Known as the Crosley Flea (but nicknamed La Cucaracha), the airplane made its debut – and final flight – at a Miami airshow that year. After being stored for about 25 years, the Crosley Flea was donated to the Smithsonian. It was restored by Patrick Packard and Patti Koppa at the Experimental Aircraft Association Museum in 1991, and today is on display at the Museum's Steven F. Udvar-Hazy Center in northern Virginia.

DANE PENLAND

The Flea's designer, Henri Mignet, claimed that anyone who could nail together a packing crate could construct an airplane.

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An Extra Two Seconds

IN THE COCKPIT of the sleek, black aircraft slung underneath the wing of the B-52 bomber, my interphone crackles. "Ah, Robert, it's a lovely morning," says Jack Allavie, the commander of the B-52 launch aircraft.

"Yes it is, Jack," I respond while running through the preflight checklist for our July 17, 1962 mission.

The North American Aircraft X-15 was designed to investigate flight at hypersonic (Mach 5-plus) speeds and extremely high altitudes, and the effects of aerodynamic heating on aircraft surfaces. It was the first aircraft to fly Mach 4, Mach 5, and Mach 6—and I had the good fortune to be the pilot of these flights. I was also the first to fly faster than 3,000 mph and the first to fly above 200,000 feet. Today we would try to best that altitude by another 100,000 feet.

I finish the checklist. The flight has been aborted three times, so the crew—drop pilots Allavie and Harry Archer and panel operator Stan Butchart—is anxious to get it going today. Fellow X-15 pilot Joe Walker will be "NASA 1," mission control on the ground. Walker and I, with Scott Crossfield and Forrest Peterson, are to fly to Washington, D.C., later today to meet with President Kennedy. He'll present us with the Collier Trophy for our work with the X-15 program—a grand honor, as the trophy is awarded for "the greatest achievement in aeronautics...in America" each year.

Allavie fires up the B-52 and requests ground control clearance to taxi out: "Eddie tower, this is zero-zero-three, taxi."

"Ready to roll, buddy?" Jack radios.

"Ready when you are, Jack." As we taxi, the starters and ladders are pulled away from the F-104 and T-38 for chase pilots Jim McDivitt and Jack McKay.

I hear Allavie over the interphone: "Say Bob, the temperature is up a bit. It's going to be a long run to unstick today"—meaning the B-52 will need a long ground run to get airborne. He knows he just opened the door for some fighter-versus-bomber banter, and I do not disappoint. "Sure you and Harry can manage, Jack? I'll be happy to crawl over and give you a hand if you have any little problems."

"Bob, you know we never let beginners fly this thing," he replies. "You just stick to your toy airplanes and leave the real flying to the pros."

The climbout goes smoothly. The drop pilots will breathe easier after we pass 26,000 feet. Below that altitude, they cannot release the X-15 in an emergency; I would not have enough time to fully jettison the propellants. The excess weight of residual propellants would result in a faster-than-normal landing, and that extra weight could cause structural failure. We had discovered the problem when an X-15 landed with residual propellant: Its fuselage buckled and landing gear collapsed. Above 26,000 feet, the X-15 pilot can either bail out or vent the tanks and land.

During our ascent some of the

AS ALLAVIE ROLLS THE B-52 ONTO THE HEADING OF 222 DEGREES, AT THE LAUNCH SPEED OF 0.82 MACH, I START THE FIRST-STAGE IGNITION. THINK OF THIS AS A PILOT LIGHT ON A GAS STOVE; THERE IS NO REAL POWER YET BECAUSE IT'S "IDLING." JOE WALKER CALLS THE COUNTDOWN: "FOUR...THREE...TWO...ONE...*LAUNCH!*"

AIR FORCE FLIGHT TEST CENTER HISTORY OFFICE (2)

liquid oxygen (LOX) has boiled off. I have the panel operator top it off. I'll need all the fuel and oxidizer I can get to surpass 300,000 feet.

We've been flying northeasterly en route to the Delamar Lake launch point. Allavie has to time his 180-degree turn to launch me precisely:

Intensive preflight inspections and preparation (above) helped ensure a flawless X-15 drop (left) from the B-52.

Being slightly off course could greatly displace the X-15 from the planned route, especially during reentry.

Initially, the B-52 pilot dropped the X-15. But if a pilot tried to yell over the interphone that he wasn't ready, he might not be heard, and on one flight, the X-15 was very nearly dropped before the pilot was ready. Now the X-15 pilot has complete control of the drop.

One minute prior to launch, I see that a glitch causes the Minneapolis Honeywell MH-96 flight control system to shut down. The "Mini-Honey" takes into account the variables that occur over a vast range of altitudes and speeds—temperatures, atmospheric and dynamic pressures, and more. Without it, the aircraft might not be controllable during reentry. (A precursor to the "fly by wire" systems in virtually all current military aircraft, the MH-96 made the X-15 easier to control with either the aerodynamic control system for flight in the atmosphere or the reaction control system, which was used at very high altitudes where there is no discernible atmosphere.)

Standard procedure says to abort if this system is not working. The MH-96 had been thoroughly tested in prior flights by Neil Armstrong, and performed well. So it's understandable that when a shutdown occurs, things get a little tense in mission control and on board the B-52.

I do a reset; the MH-96 comes back.

As Allavie rolls the B-52 onto the heading of 222 degrees, at the launch speed of 0.82 Mach, I start the first-stage ignition. Think of this as a pilot light on a gas stove; there is no real power yet because it's "idling." Joe Walker calls the countdown: "Four...three...two...one...LAUNCH!"

I flick the "Drop" toggle switch. The X-15 falls away and I shove the throttle forward. The acceleration is tremendous, and as I pitch up in a 40-degree climb, the G-forces build. X-15 pilot Bill Dana was fond of saying that because of the 4 Gs against the chest endured during powered flight, the X-15 is the only aircraft in which he was glad when the engine quit.

The plan called for an 80-second burn to reach 282,000 feet and Mach 5.15. But this engine performed very well, and by topping off the LOX, I was able to burn the engine for an extra two seconds, which allowed me to accelerate to Mach 5.45 and peak at 314,750 feet, becoming the first person to fly an aircraft above 300,000 feet and also the first pilot to fly a winged vehicle into space.

The X-15 now starts to decelerate. I can feel the MH-96 firing. At this altitude my standard controls are ineffective, so the MH-96 is now using jets of hydrogen peroxide to control yaw, pitch, and roll, keeping the nose on the proper heading.

While I am enjoying the view, I startle Walker when I transmit: "There's something out there." He does not know if I mean something is going wrong with the flight, or if something is out there flying along with me.

No time to worry about this now; reentry is fast approaching. When it begins, the "eyeballs out" negative G forces start to build. I place my helmet against the reverse headrest, which allows my helmet to settle forward slightly and stay in place as the aircraft decelerates and the pressures on my body increase. Without this headrest, the negative G forces would push my head so far forward I could lose sight of the control panel.

The X-15 soon encounters enough atmosphere to regain the use of the aerodynamic control surfaces. Coming out almost directly over Edwards Air Force Base, we are still at Mach 3-plus and around 75,000 feet, much faster and higher than previous X-15 flights. Overflying the landing site, I make one circle and roll out on heading, having lost enough altitude to be right on target for the lakebed runway. The Gs are so great that after the flight I find a huge patch of burst capillaries all over my right shoulder and chest (it disappears after a few days).

I was highly satisfied with the touchdown, but I had to get ready for the flight to Washington, so there was no time for a formal debrief. However, some of the engineers and staff did ask me about my comment that there was "something out there." I described the object as the color of cardboard, about six feet by six feet, and explained that it flew formation with me briefly. They scratched their heads and looked at me funny, but let me go.

Later, the engineers and others reviewed the film from a wide-angle camera mounted above and behind the cockpit, facing rearward. The footage showed something flying by. To this day no one is sure what it was, but the consensus is it was likely ice that had broken loose.

At the time, four Americans had earned astronaut wings: Project Mercury's Alan Shepard, Gus Grissom, John Glenn, and Scott Carpenter. With that X-15 flight, I became the fifth.

ROBERT M. WHITE

AS TOLD TO AL HALLONQUIST

It Started off Bad and Went Downhill

The author went on to fly anti-submarine P2V Neptunes.

ON NOVEMBER 30, 1955, I was scheduled for a critical flight in the basic phase of Navy flight training—the Phase C check ride—at North Whiting Field, near Pensacola, Florida. Check ride instructors had reputations ranging from somewhat easy to an almost certain "down"—a washout.

With luck, I had made it through previous check rides, so I studied hard and got to the hangar early. On the scheduling board was my name, the name of my instructor—one of the easy ones—and the assigned airplane.

The instructor briefed me on what he expected. He suggested that I preflight the North American SNJ and he would meet me at the airplane.

I took our parachutes out to the airplane and began the inspection. When the instructor arrived he asked how it was going. "Fine, so far," I said.

"Good, but shouldn't you preflight the airplane we're going to fly?" I had been diligently inspecting the airplane next to the one we were assigned.

To board the front cockpit of the SNJ, you moved from the wing to several steps on the side of the fuselage to the cockpit. You had to start off with the proper foot or you could end up sitting backward unless you could pull some elaborate and awkward footwork, and it was impossible to make these boarding adjustments subtly. Mine were painfully obvious. I heard the instructor utter a dismayed moan as he climbed into the back seat.

I couldn't get the engine to start. When the instructor tried, it started right away. I called the tower for taxi clearance but I forgot our aircraft number, and the ID plate on the instrument panel wasn't readable. "Willy Charlie 502," the instructor told the tower.

To see over the nose of the SNJ to taxi, I needed several cushions under me in addition to the parachute pack. Of course, I had forgotten to bring my cushions.

After receiving takeoff clearance, I was able to get us airborne and out to the practice area. My slow-flight demo resulted in an entry to an inadvertent stall, which led to an inadvertent spin. I knew the spin recovery procedure perfectly well: hard opposite rudder and forward stick. So naturally, I applied hard opposite stick and positive spin-direction rudder. I then flubbed traffic pattern work.

After about 20 minutes of this, the instructor said, "Bill, I think we've had enough for now—at least I have. Please take us back to Whiting, if you think you can find your way." I did find Whiting, and made a terrible approach and several lousy two-point landings: left main gear, tail wheel; right main gear, tail wheel; right main, left main. I taxied back to the ramp.

Remember how I couldn't get the engine started? Now I couldn't get it to stop: It kept pre-detonating, smoking, and shaking. Of course the instructor shut it down with no problem.

We climbed out of the airplane. I did get the exit sequence right, except for slipping off the trailing edge of the wing. We took our parachutes, and following protocol, I reached for the instructor's parachute. "I'll carry it," he said. "I'm afraid you'll drop it or carry it by the D-ring."

We sat in the debriefing area. I had a brainstorm: I asked if I could "self-debrief," rather than have him do the debriefing. "Well, I suppose so," he said, "if you've got all day."

I began with preflighting the wrong airplane and proceeded through the long list of my errors. He followed along with his notes, and as I recounted each event, he nodded and checked it off his list. Several times he said, "Aha! I missed that one!" and scribbled more notes.

I finished. He retrieved my flight training records and asked how many "downs" I had so far. When I told him I had none, he rolled his eyes and began leafing though my records.

After a few minutes he said, "You had a really bad day, didn't you? Let's call this fiasco an incomplete check ride and try it again this afternoon."

A really bad morning; a much-improved afternoon.

WILLIAM J. ONDERDONK

PHOTOS BY ALEXANDER HAFEMANN/ISTOCKPHOTO AND WILLIAM J. ONDERDONK; PHOTO ILLUSTRATION BY THÉO

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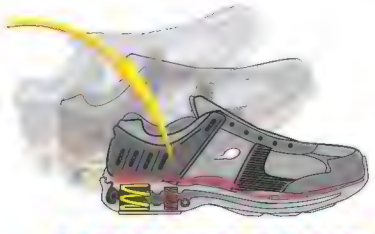

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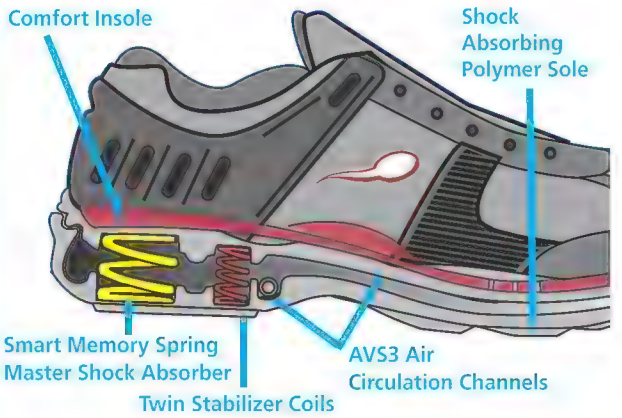

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2010 AIRSHOW GAWKER'S GUIDE

WHERE AIRPLANE FANS CAN FIND SUMMER'S BEST SIGHTS.

SINCE JANUARY 1910, when audiences crowded the bleachers for what promoters called an "aviation tournament" in Los Angeles, Americans have made flying a favorite spectator sport. But U.S. airshows do more than entertain. They inform audiences about airplanes in the current U.S. military inventory and educate them about aviation history. All U.S. services send aircraft to shows for static displays, so fans can get a close look at what their tax dollars bought—and can pepper the pilots with questions. Shows also let owners of rare, vintage aircraft show off their beauties. We've canvassed airshows across the land to find out what will dazzle the fans this year. Flying or not, these airplanes are worth a trip to a local show, where you can gawk to your heart's content.

—The editors

An F/A-18 pilot educates visitors at the 2009 New Orleans airshow (above); Oshkosh audiences employ requisite show gear: sunglasses, cameras (above, right).

TOP: ARNOLD GREENWELL; BOTTOM: US NAVY/JOHN P. CURTIS

In the Beginning, There Was Blériot

1909 BLÉRIOT XI (AND OTHER VINTAGE AIRCRAFT AND REPRODUCTIONS)

Approximately the front third and rear third of Old Rhinebeck's Blériot was original when it was donated in 1952. It is the oldest airworthy aircraft in the United States.

It has been my honor to fly the Blériot at Old Rhinebeck. Since it has no flying instruments, I have no idea how fast it flies, but would guess around 30 mph. At such slow speeds, the wing warping it uses for roll control is marginally effective. The four-cycle, 35-horsepower engine has a single magneto and starts and runs well, but having only three cylinders, it fires every 240 degrees of rotation—which is to say firing is not the smoothest. Who knows how much horsepower it still produces? The aircraft barely makes enough speed for takeoff, and with its highly cambered airfoil, it seems to levitate as much as fly. In flight it feels like I imagine a butterfly would, affected by the slightest wind change. The margin between stall and level flight is only a couple of knots. I don't recommend flying the Blériot any higher than you are willing to jump.

The landing gear is nicely sprung on bungees, so the airplane lands graciously. The gear will caster for any drift, which makes for a nice crosswind touchdown, but also a total lack of directional control. On the ground, the airplane cannot be manuevered unless people hold the wingtips.

The Blériot is the worst-flying airplane I have flown, and one of the most satisfying. Sitting in its wicker seat, surrounded by a century of incredible history and patina, I fly it with the same anticipation of the unknown as Louis Blériot must have felt.

HUGH SCHOELZEL, PRESIDENT,
OLD RHINEBECK AERODROME AIR SHOWS

Old Rhinebeck Aerodrome, Norton Road, Rhinebeck, New York (Exit 19, New York State Thruway)
Shows every Saturday (History of Flight 1909–1939) and Sunday (World War I), June 12 through Oct. 17, 2–4 p.m., weather permitting. Museum open daily 10 a.m.–5 p.m.

GILLES AULIARD

At Old Rhinebeck Aerodrome, Hugh Schoelzel channels Louis Blériot in the nation's oldest flying aircraft.

How fighters have grown! An F-22 dwarfs the P-51 and F-86 in a Heritage Flight at the California Capital Airshow in Sacramento. The formation represents more than 65 years of U.S. airpower.

When the Raptor Arrives, Look Up

LOCKHEED MARTIN F-22A RAPTOR

WHEN THE U.S. AIR FORCE F-22 Raptor comes to an airshow, static displays don't cut it; you have to see it fly. Since 2006, U.S. Air Combat Command has been sending its premier air dominance fighter to perform at airshows—12 in 2009—perhaps to build support for adding more F-22s to the inventory. (That dream died with a Senate vote last July to hold production at 187 aircraft.) With thrust-vectoring engines that together produce 70,000 pounds of thrust, the Raptor combines agility and power in an aerobatic display that nothing else on the show circuit can approach. In one of its most breathtaking maneuvers, the F-22 does a vertical climb, pauses and hangs at the top for what seems like seconds, then executes the tightest somersault you'll ever see a fighter perform. When it resumes flying like a normal airplane, the audience feels a sense of relief, and the pilot gives a wink by cycling the bomb-bay doors.

Demo pilots are fond of saying that the supermaneuverability they exhibit at airshows, while handy in the unlikely case of a dogfight, isn't the quality that will make the Raptor dominant in combat. What makes it fearsome are its speed, stealth, and networked avionics. What scares adversaries about the F-22? The one that shoots you is not the one you see.

On the ground, don't try to sneak up behind a Raptor with a camera. In fact, you can't. The Air Force is very protective of the classified thrust-vectoring hardware in the engine exhaust nozzles. You can only gawk at the Raptor head-on.

Visit ***www.acc.af.mil/aerialevents/f22a*** for updates on where the F-22 will perform.

TYSON RININGER

Love Is a Many-Bladed Wing

1932 PITCAIRN PA-18 AUTOGIRO

OVER THE PAST 11 YEARS, Jack Tiffany, working with the Leading Edge Aircraft restoration crew in Spring Valley, Ohio, led an effort to return a Pitcairn PA-18, the model Tiffany says was meant to be Everyman's Autogiro, to flying condition. "Been enamored by autogiros all my lifetime," Tiffany says. "Evidently as a child I saw one fly at Wright Field when the Army Air Corps was testing them. I was told I saw it fly; I don't remember!"

What Tiffany restored is a descendant of the aircraft that aeronautical engineer Juan de la Cierva first demonstrated in 1923, when he introduced rotary-wing flight to Spain. Six years later, American aircraft designer Harold Pitcairn purchased the rights to Cierva's invention, and in the early 1930s he built some 50 autogiros, some for private use, some for the U.S. Navy. Ultimately, the technologies derived from the development of the autogiro gave rise to the practical helicopter.

Tiffany's stepson first alerted him to the autogiro's existence in Mojave, California. "We drug the carnage home and pulled it in the shop," says Tiffany, "and [Leading Edge crew member] Don Siefer put numbered tags on every part and took photographs of it before he'd let us touch it."

Well before Tiffany even thought he might someday find an autogiro, he called Harold Pitcairn's son, Steve, looking for drawings. "I told him I'd like to build one. He said, 'You could not build that airplane without one to look at, even if you have a plan in your hand. It is unbelievably complicated.' And I'd been building airplanes for 30 years."

Challenges included identifying, locating, and fabricating parts, virtually all of which were unique to the autogiro. The fuselage required welding repair, and the rotor dampeners had to be rebuilt. "We hunted for the rotor brake—it turned out to be a Crosley brake, and there were a lot of Ford car parts in it too," says Tiffany. We had the biggest problem with the mast head that the rotor attaches to—it is a weldment, or tubing that is jigged up and welded together at precise tolerances. Nothing was square; it had to lean over a degree and a half, it had to tilt back two degrees, and then it had to be welded to the front and rear mast poles. It was a nightmare; we went to four different machine shops, and all of them threw up their hands and gave it back to us. A machinist in Albuquerque ended up making it."

Other hurdles included satisfying Federal Aviation Administration paperwork requirements so that Tiffany and his partner on the project, Jim Hammond, could register the autogiro and then apply for its airworthiness certificate; and finding someone qualified to fly it. To fly such an aircraft, a pilot must have a rotorcraft-gyroplane rating. Virginia resident Andrew King was willing to complete his instruction and check ride in Alabama.

King says that flying the PA-18 is "like being carried off by a prehistoric bird. There are these little tiny wings out there. When I turn, the shadow of the rotor blades is moving so slowly across the wing, you think: *That can't be holding this thing up either.* It flies pretty well."

SPARKY BARNES SARGENT

Sun 'n Fun, Lakeland, Florida, *April 13-18*

GREG MOREHEAD

Autogiro pilot Andrew King (rear cockpit) says flying the Pitcairn PA-18 is "like being carried off by a prehistoric bird." The exotic autogiro of the 1930s made huge contributions to the development of the practical helicopter.

On the Road Again

MIDDLE AMERICA, this one's for you: a traveling airshow that re-creates a time when an airplane landing near your town was the event of the summer, and townsfolk watched the horizon for the return of the barnstormers. This summer the American Barnstormers are flying 20 Golden Age charmers on a seven-city tour across the northern Great Plains. Love open-cockpit flying? On this third tour, the American Barnstormers will once again sell biplane rides in a Travel Air, New Standard, or Stearman.

Mason City Airport, Mason City, Iowa *June 17-19*

Marv Skie-Lincoln Airport, Tea, South Dakota *June 20-22*

Watertown Regional Airport, Watertown, South Dakota *June 23*

Aberdeen Regional Airport, Aberdeen, South Dakota *June 24-26*

Bismarck Airport, Bismarck, North Dakota *June 27-29*

Jamestown Regional Airport, Jamestown, North Dakota *June 30-July 2*

Chandler Field Airport, Alexandria, Minnesota *July 3-5*

Bone Is the New Black

BOEING (ROCKWELL) B-1B LANCER

That Old Black Magic that is the Boeing (Rockwell) B-1 bomber mesmerizes a crowd at the Miramar airshow in California.

RUMOR HAS IT that the B-1 got its insider nickname, Bone, from a newspaper story that spelled out its designation as "B-One." What is known for certain is that all the cool kids prefer Bone to the official Air Force name, "Lancer." Designed as a long-range strategic nuclear bomber and declared operational in 1986, the variable-sweep B-1B was converted to a conventional bomber at the end of the cold war. With its wings swept, the Bone can reach 900 mph at sea level, but over most locales such fly-bys are forbidden because they cause sonic booms. But even when it's just sitting on the ramp, the elegant matte-black B-1B is a real eyeful.

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TIM LACHENMAIER

Dyess Big Country Airfest, Dyess Air Force Base, Abilene, Texas, *May 1*

Static display and flybys

SkyFest 2010, Fairchild Air Force Base, Spokane, Washington,

July 24 & 25, static display

The American Barnstormers will tour the northern Great Plains and sell biplane rides in 2010.

GILLES AULIARD

Jumping Jet Flash

BAE SYSTEMS FA2 SEA HARRIER

THE PROTOTYPE of the Harrier jump jet, the Hawker P.1127, debuted in 1960 in the United Kingdom, and the United States soon jumped in with both feet: By the early 1970s, the vertical-takeoff-and-landing Harrier was flying with the Royal Air Force and the U.S. Marine Corps. (The Marine Corps always gets the divas: the Corsair, the Harrier, the Osprey.) McDonnell Douglas teamed with British Aerospace to produce the upgraded AV-8B Harrier II, which has been operating since 1985.

When some Harriers reached retirement age, a U.S. civilian decided he had to have his very own diva. The vertical-takeoff-and-landing Sea Harrier, a British naval version of the Hawker Siddeley Harrier GR1, is best known for its performance in the 1982 Falklands War with Argentina. The Royal Navy retired the aircraft in 2006, whereupon Art Nalls, who had logged 1,800 hours in U.S. Marine Corps Harrier AV-8As and Bs, bought one through an aircraft broker working with the British Ministry of Defence. The 120-decibel (chainsaw-loud) twin-engine jet made its civilian debut in October 2008, and flew six shows in 2009. Nalls told one of the airshows where he demonstrates the airplane that he needs money to help cover costs such as fuel—the airplane burns nearly two gallons per mile. "They gave me a set of Legos last year," he says, "and it's the thought that counts."

ARNOLD GREENWELL

A Marine Corps AV-8B seems to balance on its own Wall of Sound at the mother of all airshows in Oshkosh, Wisconsin.

Wings Over Pittsburgh, Pennsylvania, *Sept. 11*

Culpeper AirFest, Brandy Station, Virginia, *Oct. 9*

The Marine Corps demonstrates its AV-8B Harrier:

Florida International Airshow, Punta Gorda, *April 10 & 11*

Central Texas Airshow, Temple, *April 30–May 2*

Department of Defense Airshow, Andrews AFB, Maryland, *May 15 & 16*

Salute to Veterans, Columbia, Missouri, *May 29 & 30*

Golden West Regional Fly-in, Marysville/Olivehurst, California, *June 11–13*

Battle Creek Airshow, Michigan, *July 1–4*

Gary Airshow, Indiana, *July 10 & 11*

Arctic Thunder, Anchorage, Alaska, *July 31 & Aug. 1*

Oregon International Airshow, Hillsboro, *Aug. 20–22*

Atlantic City Airshow, New Jersey, *Aug. 25*

New York City Airshow, Brooklyn, *Aug. 28 & 29*

Little Rock Air Force Base Airshow, Arkansas, *Oct. 9 & 10*

Happy 75th Birthday

DOUGLAS DC-3, BOEING B-17

FOR U.S. AVIATION, 1935 was a very good year. It was the year that C.R. Smith, the new president of up-and-coming American Airlines, got an edge on his competition. Hoping to win customers by offering more comfort on long coast-to-coast trips, Smith asked Donald Douglas to design a modern "sleeper," so passengers could spend part of the journey tucked into Pullman car-type berths. Douglas answered, reluctantly, with the Douglas Sleeper Transport, which, in its daytime configuration, was the 21-passenger DC-3 ("DC" for Douglas Commercial). Its first flight was December 17, 1935, the anniversary of *the* first flight, and six years later, 80 percent of the airliners flying in the United States were DC-3s. It was the first airliner that made money for its operators from passenger fares alone, independent of mail contracts. Airplane fans have loved it from the beginning.

Also in 1935, just five months before the DC-3 made commercial aviation profitable, Boeing Aircraft Company launched the B-17, the aircraft that would determine the course of U.S. military aviation. The country's first operational four-engine bomber took off from Seattle's Boeing Field on July 28, 1935; more than 12,700 (some built by Douglas and Lockheed) would follow. A *Seattle Times* reporter coined the name "Flying Fortress," but he could not

***Nine O Nine*, a B-17 owned by the Collings Foundation (top), tours the country yearly, to the delight of World War II veterans. Opposite: Four DC-3s squat at attention at Oshkosh in 2009.**

These organizations fly B-17s; some sell flights and post tour schedules on their Web sites:

1941 Historic Aircraft Museum, Geneseo, New York

Collings Foundation, Stow, Massachusetts

Commemorative Air Force, Midland, Texas

Commemorative Air Force, Mesa, Arizona

Evergreen Aviation Museum, McMinnville, Oregon (this year: only static display)

Experimental Aircraft Association, Oshkosh, Wisconsin

Liberty Foundation, Tulsa, Oklahoma

Lone Star Flight Museum, Galveston, Texas

Lyon Air Museum, Santa Ana, California

Palm Springs Air Museum, Palm Springs, California

Vintage Flying Museum, Fort Worth, Texas

Yankee Air Museum, Ypsilanti, Michigan

MAX HAYNES/MAXAIR2AIR.COM

Paris + Jet = Trés Magnifique

MS760

IT DOESN'T HOVER or breathe fire or autorotate, but when it debuted in the 1950s, the world's first Very Light Jet was very far ahead of its time. The Morane Saulnier Paris MS760 was designed as a jet trainer to meet a French military contract, but it lost the competition. Beech Aircraft bought a few and demonstrated them as business jets Stateside, but the Learjet soon eclipsed the Frenchie. Late last year a U.S. entrepreneur announced plans to update 32 Paris jets and sell them for about $550,000 per (training included). A two-ship precision-flight team, led by former F-14 demo pilot extraordinaire Dale Snodgrass, is flying the circuit this summer.

PAUL BOWEN/AIRTOAIR.NET

"The Last Time We Saw Paris," it had morphed from a 1950s military trainer to the next potential Very Light Jet.

Sun 'n Fun, Lakeland, Florida, *April 13-18*

Air Lauderdale Beach Fest, Ft. Lauderdale, Florida, *April 24 & 25*

Sun Fun Festival Airshow, Myrtle Beach, South Carolina, *May 28 & 29*

Borden Canadian Forces Day, Canadian Forces Base Borden, Ontario, *June 5 & 6*

Rhode Island National Guard Open House, North Kingston, *June 26 & 27*

EAA AirVenture, Oshkosh, Wisconsin, *July 26-Aug. 1*

Atlantic City Airshow, New Jersey, *Aug. 25*

Boston-Portsmouth Air Show at Pease, Portsmouth, New Hampshire, *Aug. 28 & 29*

Naval Air Station Oceana Air Show, Virginia Beach, Virginia, *Sept. 18 & 19*

National Business Aviation Association Convention, Atlanta, Georgia, *Oct. 19-21*

Wings Over Homestead, Homestead Air Reserve Base, Florida, *Nov. 6 & 7*

have foreseen how vulnerable the bomber crews would be to anti-aircraft guns and enemy fighters in World War II. As wave after wave of B-17s—some formations more than 200-strong—began to pound German industrial centers in 1943, losses were so heavy that missions were curtailed. (Once the P-51 Mustang fighter began escorting the bombers, their chances of survival improved.) The drama of those missions and the B-17's good looks made it a media darling, and today a dozen U.S. organizations fly restored B-17s as symbols of sacrifice and triumph.

This July, at the 2010 Experimental Aircraft Association's AirVenture fly-in at Oshkosh, Wisconsin, the DC-3 and B-17 will get together to celebrate their 75th birthdays. Some 25 DC-3s will fly in, and the EAA expects several B-17s to show up.

JIM RAEDER

Simply the Best

Is there an airshow fan alive who doesn't know the legend riding beneath that hat?

by Debbie Gary

THE FIRST TIME I SAW BOB HOOVER FLY I was a new show pilot standing next to the great Curtis Pitts and hoping for words of wisdom. It was March 1972, and Pitts and I were watching the airplane he created perform at Miami's Tamiami Airport. The sky was a frenzy of tiny Pitts Specials panting through snap rolls and outside loops. It was noisy, and Pitts said nothing during the performance. Even after the airplanes landed and Hoover taxied out, Pitts was quiet—until Hoover, on takeoff, rolled the twin-engine Shrike Commander. It was as graceful and fluid as a cat stretching its back. The show tempo shifted from salsa to whipped cream. Pitts turned and grinned at me. "Have you ever seen anything so smooth?" he asked.

For the next 20 minutes, we watched North American Rockwell's big, beautiful cross-country transport flow through giant loops and vertical climbs, four-point rolls and half Cuban eights. Two engines roared, then only one, but the airplane kept dancing. When the second engine stopped, the roar became a glider's *whoosh*. The airplane swept past in a deadstick loop, followed by an eight-point roll, then waltzed down to the landing: LEFT two-three, RIGHT two-three, LEFT two-three—the wings banked steeply as one tire kissed the runway, skated, rolled, then lifted as the wings banked the other way, and that wheel skated, rolled.... "Now that's flying," Pitts said to me as Hoover, still without power, maneuvered up the runway and onto the taxiway, stopped precisely at show center, then climbed out in his business suit and waved his straw hat at the cheering crowd.

That Shrike and a bright yellow North American P-51 Mustang he called "Ole Yeller" were Hoover's signature showplanes, and he flew them all over the world. But they represent only two of the more than 300 types of aircraft he flew, many of those in aerobatic demonstrations. In 1938, when he was 16, he flew his first show, entertaining his family with a Piper J-3 Cub. By the end of his career, 62 years later, he had flown more shows for more people than anyone else in history.

"He was the one that everyone wanted," veteran airshow announcer Danny Clisham says. "He was

R.A. "Bob" Hoover: fighter pilot, test pilot, starter pilot at the air races, and king of the show pilots.

PAUL BOWEN/AIRTOAIR.NET

A graceful bizcraft, the North American Rockwell Shrike Commander was not designed to be an aerobatic star, but in Bob Hoover's hands, it was.

EAA

able to take four distinctly different airplanes in one day and make them all dance in a different way from any other airplane."

At 88, he is still in demand. Through a speaker's bureau, he entertains audiences with stories revealing a skill so uncanny that it enabled him to perform low-level aerobatic demonstrations in dozens of types of airplanes the first time he flew them. Once, in Moscow, he was arrested for doing that because he upstaged the Soviet pilots in their own Yak-18s. During World War II, as a military test pilot evaluating aircraft delivered to bases in North Africa, Hoover entertained his fellow airmen by improvising an aerobatic routine in a newly arrived Lockheed P-38. Perhaps his most famous first-flight story takes place at the end of the war: After spending almost 16 months in a German prisoner-of-war camp, Hoover escaped, found a Fw 190, hopped in, and flew it to Holland.

After graduating from Army flight training in 1941, Hoover flew everything he could get his hands on. "Hell, I would fly an old Dodge truck if they put wings on the side," he wrote in his autobiography, *Forever Flying*. He had such confidence and curios-

ity that he learned things about airplanes other pilots hadn't figured out, such as why the Bell P-39 Airacobra tumbled—and how to recover when it did. In the 1950s, while he was working as an experimental test pilot for North American Aviation, he developed a dive-bombing technique for the F-86 Sabre and traveled to Korea to demonstrate the maneuver for pilots flying combat missions. He also taught them how to take off with heavy loads and from short runways. There had been several fatal crashes in the Sabrejet, and Hoover's demonstrations, by several accounts, saved many lives.

As an 18-year-old Tennessee Air National Guardsman, Hoover trained as a tail gunner in Douglas O-38 observation craft.

Still at North American when the company sold the Air Force the supersonic F-100, Hoover flew a demo for the U.S. Air Force Thunderbirds that convinced the team that the Super Sabre would be the perfect airplane for them.

Even with so many aircraft in his logbook, Hoover says he still regrets the one that got away: The Bell X-1S, and the 1947 flight that broke the sound barrier. He and Chuck Yeager were test pilots together at the Air Technical Service Command at Ohio's Wright Field when Yeager was chosen for the flight. Hoover was picked as his backup. He has always said that what cost him the spot was getting caught that year making two inverted passes in a Lockheed P-80 at an Ohio airport.

He and Yeager were good friends, dogfighting over Wright Field every chance they got. Yeager recalled the period in his 1985 autobiography: "In January 1946, the skies over Wright Field were finally quiet. That's because Bob Hoover and I were sitting in class at the test pilot school on base, taking a six-month course."

As a test pilot, already famous for flying, Hoover became doubly famous for surviving: Engines exploding, ejection seats failing, wings buckling, control rods burning through, and rockets firing through the nose of an F-86 he was flying—all could have been fatal. In many of the incidents, the airplanes should have crashed, but thanks to Hoover's luck and exceptional talent, he almost always got the aircraft back on the ground. In November 1950, assigned to test a new kind of F-86 control system, Hoover took off from Los Angeles, and the system immediately failed. The F-86 nose pitched straight up, and the airplane stalled and spun toward the runway. Thinking back on the incident today, Hoover says he thought to himself, "Oh boy, this is really going

"Ole Yeller" waltzes to a landing, with Hoover touching one wheel to the runway, then the other – his signature finale to an aerobatic performance.

TOP: COURTESY AIR FORCE FLIGHT TEST CENTER HISTORY OFFICE; LEFT: TED KOSTON

In the 1970s, Hoover's demos meant sales for North American Rockwell's business craft.

to hurt." The controls were stiff as concrete, but he began to work with what he could move: the rudder, throttle, speed brakes, and flaps. "I kept trying to find the sweet spot where the forces are exactly the same on the top and bottom of the horizontal stabilizer," he says.

For the next 40 minutes, he struggled to keep the airplane in that sweet spot. A number of times he almost crashed. But he was able to wrestle the F-86 inland to an 11-mile-long dry lakebed at Edwards Air Force Base in California.

In 1994, when he was 72, Hoover fought another kind of threat. Federal Air Surgeon Jon L. Jordan revoked his medical certificate, an action that suspended his solo flying privileges. Friends, fans, doctors, lawyers, and show pilots all over the world rallied to protest. Later, Jordan wrote, "Possibly in the entire history of the conduct of the airman medical certification program, no one decision has created more controversy." On October 19, 1995, the Federal Aviation Administration reinstated Hoover's medical.

In the interim, he passed the medical and flying tests for an airline transport rating in Australia and flew the Shrike Commander in shows there, but for several years "Ole Yeller" sat without him. The P-51 Mustang is famous for the torque of its 1,425-horsepower engine. When the pilot pushes the throttle forward on takeoff, or banks the airplane steeply for a knife-edge, or gives the fighter full power while its speed drops, it takes strong legs and lots of rudder to hold the nose straight. During his siege with the FAA, Hoover's leg muscles took a holiday from the 40 years they had been fighting the P-51's torque. After the hiatus, he flew "Ole Yeller" at Nevada's Reno Air Races in 1996, a year after he got his medical back. "When I landed, everybody said, 'That was the best flight you ever made,' " Hoover recalls. "Colleen, my wife said, 'I bet you'll never sell that airplane now.' "I said, 'On the contrary. That was my last flight in the Mustang.' My knees were hurting so bad that I knew the time had come where I couldn't handle the torque. I broke both legs during an accident in my test flying career and they had gotten much worse with age, so I had been taking lots of exercise to get my knees more strength. The torque with the Mustang is really enormous, and when you're doing a knife edge, flying close to the ground, you boot the rudder even harder. It got my knees hurting so bad that when I landed, I couldn't get out of the cockpit."

Hoover sold the Mustang to John Bagley, founder of the Legacy Flight Museum in Rexburg, Idaho, who still flies it at airshows. In 2000, Hoover donated his Shrike to the National Air and Space Museum.

Representing North American Aviation, Hoover first appeared on the airshow circuit in the 1950s flying a Mustang.

Hoover had flown the P-51 as the official pace plane of the National Championship Air Races from the very first race, in 1964, until 1990, and race fans loved him.

"At the Reno Air Races," says Danny Clisham, "he performed in four different airplanes, flew the pace plane, warmed up the crowd before the race, and entertained them [after the last race] when the Unlimiteds were landing. In four days, he would make 28 different flights."

That stamina had been Hoover's trademark from the beginning. His boyhood dream was to be a fighter pilot, but when he paid $2 for his first 15-minute lesson, he discovered something horrible: Flying made him airsick. For almost a year, every flight nauseated him. When he finally got to fly solo, he chose an unusual course and it has defined his life. He decided to loop, roll, and spin the Piper Cub until his stomach was conditioned. It worked. By the time he got to Army Air Corps training, he was the best aerobatic pilot anyone had seen, and it set the course for his one-of-kind flying career.

The greatest generation in aviation: (from left) Chuck Yeager, Hoover, and triple P-51 ace Clarence "Bud" Anderson at the Experimental Aircraft Association's Oshkosh, Wisconsin airshow.

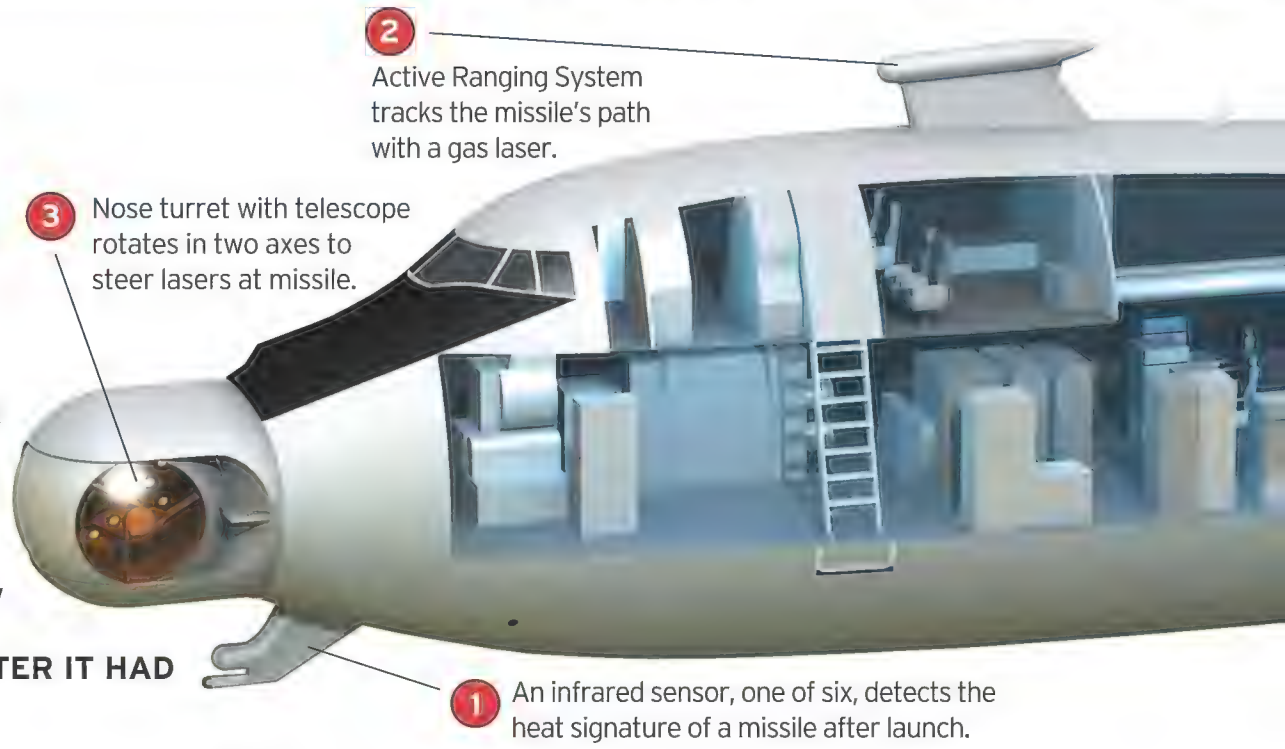
BOB MILLER

TOP: NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA); FAR RIGHT: COURTESY JOHN CIANCI

How Things Work:

Missile K

BY DAMOND BENNINGFIELD | ILLUSTRATION BY JOHN MACNEILL



LAST FEBRUARY, OFF THE CALIFORNIA COAST, MILITARY AEROSPACE ACHIEVED A FIRST: AN AIRPLANE FIRED A LASER, DESTROYING A MISSILE SHORTLY AFTER IT HAD BEEN LAUNCHED. HERE'S HOW.

The laser is one of several being developed by Boeing, Lockheed Martin, and Northrop Grumman. While some lasers are being designed to attack battlefield targets at close range, this high-energy, megawatt, chemical laser on board a modified Boeing 747-400F is specifically designed to destroy all classes of ballistic missiles during the first few minutes after launch.

Though the technology appears to work, its huge cost will clip the Airborne Laser's wings. Last spring, Secretary of Defense Robert Gates cancelled a second test aircraft and eliminated plans to deploy operational Airborne Lasers. He is allowing the test program to continue with the remaining 747, now called the Airborne Laser Testbed, because it is contributing to a broader understanding of directed-energy weapons.

An engineer adjusts the beam-control optics that ride in the nose of the Airborne Laser Testbed, a modified Boeing 747-400F. The optics stabilize and shape the weapon laser's beam as it is aimed by the nose turret's computer-controlled telescope at a target missile.

LOCKHEED MARTIN

In combat, the airplane would orbit at about 40,000 feet near the front lines of a battle or as close to enemy missile sites as possible. Six infrared sensors on the airplane's fuselage **[1]** would detect a missile as it climbed above 40,000 feet at a range of up to "a few hundred kilometers," says Mike Rinn, Airborne Laser program director for lead contractor Boeing (a kilometer is .62 mile). Like many details about the weapon, the exact range is classified.

Atop the fuselage, the Active Ranging System **[2]** , a modified electronic targeting pod like those used by fighter airplanes, would acquire the missile and track it with a high-power gas laser to determine its launch and impact points. An onboard computer system would identify and classify the missile as an enemy target. Then, inside a bulbous turret in the 747's nose **[3]**, a telescope with a 50-inch-diameter mirror would turn toward the missile.

Next, a Tracking Illuminator Laser **[4]** would fire four narrow beams at the target, and the telescope would detect their reflection, refining the distance and direction to the missile.

A Beacon Illuminator Laser **[4]** would then fire four more beams to measure distortions created as these beams passed through air masses of different temperatures and densities, which

iller

4 Tracking and Beacon Illuminator Lasers refine targeting information.

5 Six chemical modules create the power to fire the weapon laser.

Warfare at the speed of light: Boeing says detection to destruction (top) happens in a matter of seconds.

bend light in different directions. Once the distortions were measured, the system would compensate for them by reshaping small mirrors hundreds of times per second. This would be accomplished by hundreds of tiny electric actuators, or pistons, similar to the adaptive optics used in ground-based astronomical telescopes. Reshaping the mirrors allows them to reflect the final, high-power, weapon laser in a way that focuses its energy to counteract the atmospheric effects, and aims the narrowest possible beam at the target.

The weapon is a Chemical Oxygen Iodine Laser **[5]**, which uses a combination of hydrogen peroxide, potassium, sodium, and lithium hydroxide ("Think Drano," Rinn says). In the back of the 747, the chilled laser fuel would be sprayed through a grid of pores like a showerhead, and passed through a mixture of chlorine and helium to produce a form of oxygen. The oxygen is then injected with iodine gas, which excites it and produces photons that are intensified to create the infrared laser beam, which exits the nose turret. The challenge is to create enough energy for the beam to maintain strength and duration over the distance to a target missile. In a few seconds, the beam heats the missile enough to rupture its fuel tanks and destroy it.

"The system is extremely capable," says Rinn. "As we tune it and increase the power and decrease the jitter and make the [atmospheric] control even better, the range will go up." He adds that studies by Boeing show that the weapon could also shoot down aircraft, surface-to-air missiles, drones, and other targets.

With more successes, might the Pentagon reconsider and fund an operational system? Practical limitations would almost surely prevent it, according to Barry Watts, a senior fellow at the Center for Strategic and Budgetary Assessments. "If you want to maintain a 24-hour orbit, how many airplanes would you need?" he asks. "The answer is probably three or four." And that's just for one area of interest—the Airborne Laser was never intended for global use. "You'd probably get pretty good coverage off the east coast of North Korea, for example," he says. "Then there's the issue of having the intelligence beforehand to position the orbit in the right place so you can actually do something against boost-phase missiles. Gates' position was that we're not going to buy a large enough fleet of these things to be able to fulfill realistic operational requirements."

Watts could see a high-energy chemical laser on the ground. "Israel has a small area to defend," he says. "They could hook [a big chemical] laser up to a ground-based industrial system. That makes a lot of sense for their problems. For the U.S., with so much more territory to defend, that would get expensive fast." One day, the laser may be able to reach targets far higher than boost-phase missiles. "You could put a big one on the ground and mess with people's satellites," says Watts. Airborne or not, it looks like lasers have arrived.

GRAB THE AIRPLANE AND GO

HOW TO REPOSSESS AN AIRLINER WITHOUT GETTING SHOT, OR THROWN IN JAIL, OR BEAT UP, OR SLAMMED INTO A WALL, OR...

The next Airbus A340 you see flying could be a repossession under way. The crew at Sage-Popovich has made off with all kinds of airliners, from Hawkers to 747s.

ISMAEL JORDA/AIRTEAMIMAGES

"WHAT YEAR DID WE SNATCH THE PRESIDENT OF THE CONGO'S AIRPLANE?" NICK POPOVICH ASKS. OUTSIDE, CHILLY RAIN SOAKS THE PASTURES OF HIS ROLLING INDIANA COUNTRY ESTATE. FROM A POND WITH A GUSHING FOUNTAIN, WATERFOWL HONK FAINTLY.

An assistant rifles through records as Popovich assures me cheerfully, "We're not going back to central Africa soon. There's still a death warrant out for me."

Driving to Valparaiso on a two-lane blacktop, I saw only a sign with the name of Popovich's horse farm. But once I turned off the road, drove up the driveway, and entered this opulent ranch-style residence, I found a global operation ticking with the stealthy clockwork of a CIA front. From these headquarters, Popovich plots to repossess some of the world's largest aircraft. If you've been leasing a $150 million jumbo jet and missed a few payments recently, you might want to glance outside and make sure it's still there.

Popovich once flew everything from DC-8s to a Braniff Airways 747. Looking at this intense, bearded man, who favors loose-fitting flowered shirts, I had a hard time picturing him in a blue suit with braid on the sleeves, filing flight plans at a corporate hub. "I felt like a bus driver," he says. Offered a share in a Caribbean startup, he bailed on the big airlines and plunged into the shark tank of small charter ops. Some requisite financial wrangling left him owing a favor to a U.S. bank. One day in 1979, the bankers called to collect: A Sri Lankan airline was in default on two 747s, and the banker asked Popovich to bring them home.

He recruited some pilot friends and ad-libbed a grab of the colossal aircraft. Afterward, the banker advised him that for his next repo, he should charge three times as much. Popovich never looked back. He formed Sage-Popovich, Inc. (Sage is the surname of his now-ex wife), and the company has gone on to seize more than 1,200 airliners. "When times are bad," Popovich says, "it's good for us."

BY STEPHEN JOINER

The company is brought in when the dunning has run its course—the bank has sent all the official warnings, and the airline has been through the default process. It's surprising how commonly airliners get behind the eight ball, says Al Nigro. For 25 years Nigro managed leasing and financing of commercial aircraft at institutions like Bank of America and Deutsche Bank; he used to hire Popovich, and now he works for him as his vice president. "If an airline has a weak summer travel season," says Nigro, "you can pretty well predict they're going to struggle through the winter and may fall behind on their payments." Maybe a new competitor is sapping market share, or a plane-buying binge has left a carrier with a fiscal morning-after. On the other hand, he adds, "Some of them are just downright crooks. Just because the airplane is physical-

Nick Popovich in an A320 grabbed from Asia. Repos aren't personal, he says, but "sometimes you've got to get ugly and say 'You want to screw with us?' "

ly big, that doesn't mean the company that's leasing it is big—or particularly honest."

Sage-Popovich carries out about 50 recoveries a year, some of multiple aircraft. The most common target are Boeing 737s, but Popovich and his team retrieve everything from 747s to luxury executive jets. Chasing smaller stuff—the "tinker toys"—isn't cost-efficient for an operation that keeps as many as 60 people in the field at a time.

An airline's financial failure is messy, dragging down livelihoods and futures. Individual pilots and mechanics idled by a repo do get Popovich's sympathy (and sometimes offers of temporary employment). But he also says: "It's just business. It's just a financial situation." He and his team scheme airliner repossessions with cool calculation around a glossy mahogany conference table.

When banks hire the company, they don't delve too deeply into how the job will be executed. "Not that we would ever do anything illegal," Popovich says, "but they'd just rather not know how we did it. The rule is 'Don't ask, don't tell—just get our airplane back.' "

Jennifer Barlow, the company's project planner, masterminds a repossession's complex logistics. There are conference calls with banks and insurers and opinions from lawyers. Then, Barlow says firmly, "We decide what needs to be done." She does not mean putting a strongly worded reminder in the mail.

She begins compiling a three-ring binder called the Repo Book. It includes affidavits of default, power of attorney, and all the legalese required to satisfy international treaties governing the process: everything that will give the crew the rights of a lawful owner.

Sage-Popovich also makes a determination whether the repo will be "friendly" or "non-friendly." (Barlow estimates that defaulting airlines cooperate in the repossession of their airplanes less than 20 percent of the time.) In a non-friendly repo, "they're probably going to try to hide the aircraft from us," she says. As the airline continues to use the aircraft to make money, it may juggle routes and schedules to frustrate recovery. Charter aircraft, which don't fly set routes or on timetables, can be particularly elusive. One outfit (Popovich wouldn't identify carriers presently operating) repeatedly gave the repo men the slip by exploiting Egypt's loose enforcement of financial covenants. Sage-Popovich arranged for a go-between to charter the desired airplane under the guise of a lucrative U.K. tour-group contract. The eager operator flew the airliner out of its Egyptian haven and landed in repo-friendly Britain. "We just watched and waited until the crew checked into their hotel," Popovich says, "then we grabbed their plane and flew away."

The company uses online tracking services and software, but furtive airlines can block the display of tail numbers. They can run, but the Federal Aviation Administration, Transport Canada, and Eurocontrol won't hide them. Cooperative officials tip off Popovich when the airliner shows up on air traffic screens.

Once the quarry is cornered, the bank may exercise its right to an inspection, to be performed by Sage-Popovich employ-

ees. An airworthiness survey and avionics inventory are conducted. Engines are sometimes leased separately and shuffled around within an airline's fleet, so their provenance is verified. Hands must be laid on the aircraft's technical records, which the operator has sometimes placed in lockdown. Refusal to surrender them is an anti-repo ploy—an airplane without papers could be devalued as much as 50 percent. Years of expensive maintenance checks would have to be re-performed before the bank can market it. At insolvent airlines, morale is usually in the tank, so Sage-Popovich may need to identify ticked-off personnel to liberate the vital maintenance logs.

Behind standard procedure, however, lurks ulterior motive. "We try to do these inspections in a nonchalant way," Nigro says, "because often there's another purpose. It's really a reconnaissance mission to plot the repossession." What's the layout of the airport? How hard will it be to get a repo crew in and out? What routes is the airplane flying?

Back in Indiana, Jennifer Barlow is assembling the team. Pilots are hired as independent contractors. "We get hundreds of résumés," she says, paging through a binder bulging with applications. Compensation depends on ratings and specialties—and which country the pilots will be required to snatch the airplane out of and how risky the job is. In some situations, Barlow says, "pilots can pretty much name their price."

Repo pilot Kevin Lacey looks and sounds a lot like the Dennis Weaver character from the 1970s TV series "McCloud." Despite the folksy demeanor, Lacey has a reputation as a somewhat Machiavellian aero-sleuth who always gets his airplane. He thrives on the sport of it: tracking an errant commuter airliner to its gate at a big European airport, then pouncing in the hours just before passengers arrive for an early flight. When he tells you he regrets not sticking around to apologize to inconvenienced fliers, you believe him. But he's also sorry to miss "the expression on that airline agent's face when they realized their plane was gone."

Kevin Lacey, here with a repossessed Citation VII, gets the job done by striking an effective balance between folksy and wily.

Besides pilots and mechanics, Sage-Popovich sometimes recruits other specialists. In Russia and Colombia, where foreigners can be kidnapped, the company rolls with bodyguards. The extra muscle is strictly for self-defense, however. If repo resistance escalates to the physical, "you just have to walk away," Popovich says.

Well, he says that *now*. During a repo in the mid-1980s, both sides got physical. A U.S. financier had hired Popovich to snatch a Boeing 720 from a tour operator in Haiti who was in default. Though the aircraft had a book value of only $600,000, an airport manager refused to release it unless a million dollars was deposited in a Swiss bank account. Having made arrangements with an entrepreneurial Port-au-Prince airport employee, Nick showed up around midnight with an air starter (720s lack an onboard auxiliary power unit to start engines). The field had been closed for hours when the team fired up the big turbofans. As he began adding power, Popovich says, "I saw the first tracer rounds streak over the top of the airplane."

He veered to a stop and Haitian troops swarmed the airplane, bayonetting fuel cells in the wings. "I got out and shoved one of them," Nick says with a sigh. "The rest of them beat the hell out of me and threw me into the national penitentiary in downtown Port-au-Prince. A dirt-floor cell with no roof and 35 people in it." In addition to the million-buck drop in Switzerland, the Haitians wanted $150,000 to release Popovich. "The American embassy did nothing for me," he grumbles. A week later, however, the regime of dictator Jean-Claude "Baby Doc" Duvalier collapsed. The prison gates were thrown open. "Everyone ran out into the street," Nick laughs. "But that plane is still down there today. The only commercial aircraft that got away from us."

Naturally, the team doesn't appreciate a welcoming committee. "It's usually not in our interest to give them any notice that we're coming," Popovich says. The phone calls, the certified letters, the sudden inspection—executives at dysfunctional carriers hear the repo clock ticking, but the exact day of reckoning is intended to be a shock. Execution is hour- and even minute-sensitive. "We know where a plane will be at a particular moment. We may not know where it's going to be tomorrow."

At a boneyard in Victorville, California, a 747 shard bears witness to the failure of cut-rate Tower Air, whose final inventory, spread around the world, took some repo magic to round up.

TOP: COURTESY SAGE-POPOVICH, INC.; RIGHT: JUERGEN TRAUTWEIN

The Sage-Popovich storage lot in Gary, Indiana, tells a hundred stories, all ending unhappily. Above: a stripped-for-parts 737 from Brazil.

Then—rock and roll. Sage-Popovich owns a Hawker 700 and a Bombardier Challenger, executive jets that are often used for a SWAT-like opening sequence: "Flying into an airport at night, dumping my crew at the airplane we're after, and going from there," Nick says. The airplane is now their legal property, and they act like it. Says Popovich, who still attends about half the repossessions: "Sometimes you've got to get ugly and say, 'You wanna screw with us? We'll call a federal marshal and you can explain to a judge why you interfered with this repossession.' "

When the crew reaches the airliners, the sight they're greeted with isn't always pretty. Cut-rate Tower Air kept its widebody fleet flying by quietly dismantling a trio of 747s leased from GMAC and dispersing the components among its 18 other airplanes. When Tower defaulted, the repo crew arrived to find little more than a shell of GMAC's collateral. "The fuselages were still there," Popovich says, "but most of the engines, all the avionics, hydraulic pumps, flight controls, landing gear parts—missing." As Tower lurched into liquidation, Sage-Popovich rounded up 16 of the carrier's intact 747s. It was a sweep of jumbos on a global scale. "JFK, Paris, Israel—they were scattered all over the world," Nick says.

By the time the crew is ready to fly off, the hard part is usually done. Cabin doors on unoccupied airliners aren't usually locked. The safety of an airliner is predicated on its being parked in a secured location, not on the aircraft having any built-in security features. And once in, you don't have to hotwire a 747 because, like all airliners, you don't need keys to start it up.

In case of last-minute snags—like testy airport personnel refusing to tug the airplane out—thrust reversers can be used to power back from the gate. See ya.

Still, countermeasures happen. Airline employees might lock aircraft to ramp vehicles, or chain a cockpit window open so the airplane can't be pressurized. Over-loyal employees have created awkward moments: "We've had guys get on the airplane while we were taking it and refuse to get off," Popovich says. Employees have also called security to report an airliner being "stolen by terrorists." Popovich has been offered cash—$150,000 once—"and all sorts of things" as inducement not to take an airplane.

It's not just airlines that put stumbling blocks in Popovich's way; local bureaucracy can make life difficult for his team. When the French carrier Fairlines defaulted on its fleet of tricked-out MD-80s, Sage-Popovich got the call. After scoring one in Italy, Nick set his sights on another known to frequent Paris' Charles de Gaulle airport. He found it at Terminal 1, neatly surrounded by orange cones to prevent access. (Yeah, that's going to stop him.) Some sort of document—it would turn out to be a judge's order grounding the airplane due to unpaid fuel bills—was taped to the cabin door. "But it was all in French," Popovich says, "so I just tore it off."

His team ran through the checklists and lit engines. Immediately, a jeep-load of gendarmes appeared and Popovich was hauled before a magistrate. "In my infinite wisdom, I admitted that there was something posted on the aircraft's door," he recalls. "But I informed the judge that if it was really so important, it should have been in English, since that's the official language of aviation." The next day he was escorted, in handcuffs, to the first U.S.-bound flight and sent home.

Popovich and team flew to Madrid and reentered France via rail. At de Gaulle they found the MD-80 still grounded, with tanks drained and more French fine print attached. An Air Afrique Airbus next to it was being refueled. Popovich talked to the captain and got him to sell enough fuel to get as far as Iceland. "Everyone was going to be looking for us," he says, "so I wanted to get out from under Eurocontrol ASAP." He had already exercised power of attorney to de-register the aircraft from its Luxembourg flag and had obtained a U.S. registration number. The de Gaulle tower cleared the now-American plane for taxi and takeoff. Popovich landed in Iceland with less than 30 minutes' worth of fuel remaining.

In one case, government intervention dragged the repo out for months. Kevin Lacey had been assigned to get a trio of 737s out from the interior of Brazil. The airplanes belonged to state-owned VASP Airlines. For 75 years it had been the pride of Brazilian aviation, but it had gone bankrupt. Making matters worse, says Lacey, "everybody hates Americans down there anyway." And the Brazilian army wanted to retain the airliners for military use. While in Brazil, Lacey was put under house arrest, then deported. He returned, and a judge allowed him to take possession of the airplanes but not fly them out of Brazil. To keep them away from the Brazilian military, Lacey took them to the most remote airstrip he could find. Eventually, the court ruled in the company's favor, releasing two of the three airplanes. The other was ultimately paid off with insurance money and left behind.

In some countries the Sage-Popovich brand raises red flags, so to get confiscated airliners through foreign air traffic control, the repo crew has to finesse them. To file flight plans and

overflight permits, the company will enlist a third party—"Somebody with a name that doesn't carry the connotation we do," Popovich says. To spring an airplane encumbered by local financial liens, six-figure wire transfers from a U.S. bank are sometimes required too. Might payoffs to the right officials—in the sort of locales that would prefer cash—also expedite the vanishing of a multi-million-dollar airliner? Popovich quickly corrects my terminology. "We negotiate with them," he says, smiling. "It would be against the law to pay them off."

Ultimately, the perfect repo is the one that never happens. Al Nigro recalls a European carrier in default on two widebodies, and flaunting it: "Every day they kept flying those big planes full of passengers in and out of JFK [in New York City], but not paying the rent." While the lessee brazenly reaped revenue, the lessor chose the Nick Popovich nuclear option. Since it was mid-November, the repo man advised a waiting game: A seizure in December would raise the spectre of hundreds of stranded holiday travelers and lots of bad publicity. "We really weren't trying to put the airline out of business," Nigro explains. "We were just making sure we had maximum leverage against them." As the festive season approached, Popovich prepared to nab the airplanes ("It was like watching a python getting ready to strike," Nigro says), including notifying dismayed JFK airport officials of his intention. One tipped off the airline, which promptly grounded the airplanes in their home country. "Nick was furious," Nigro says, "but almost immediately the airline CEO phoned me and said, 'Okay, you've got us. We'll pay whatever we owe. Just promise not to take our planes if we come to New York.' The money was at the bank in full the next morning."

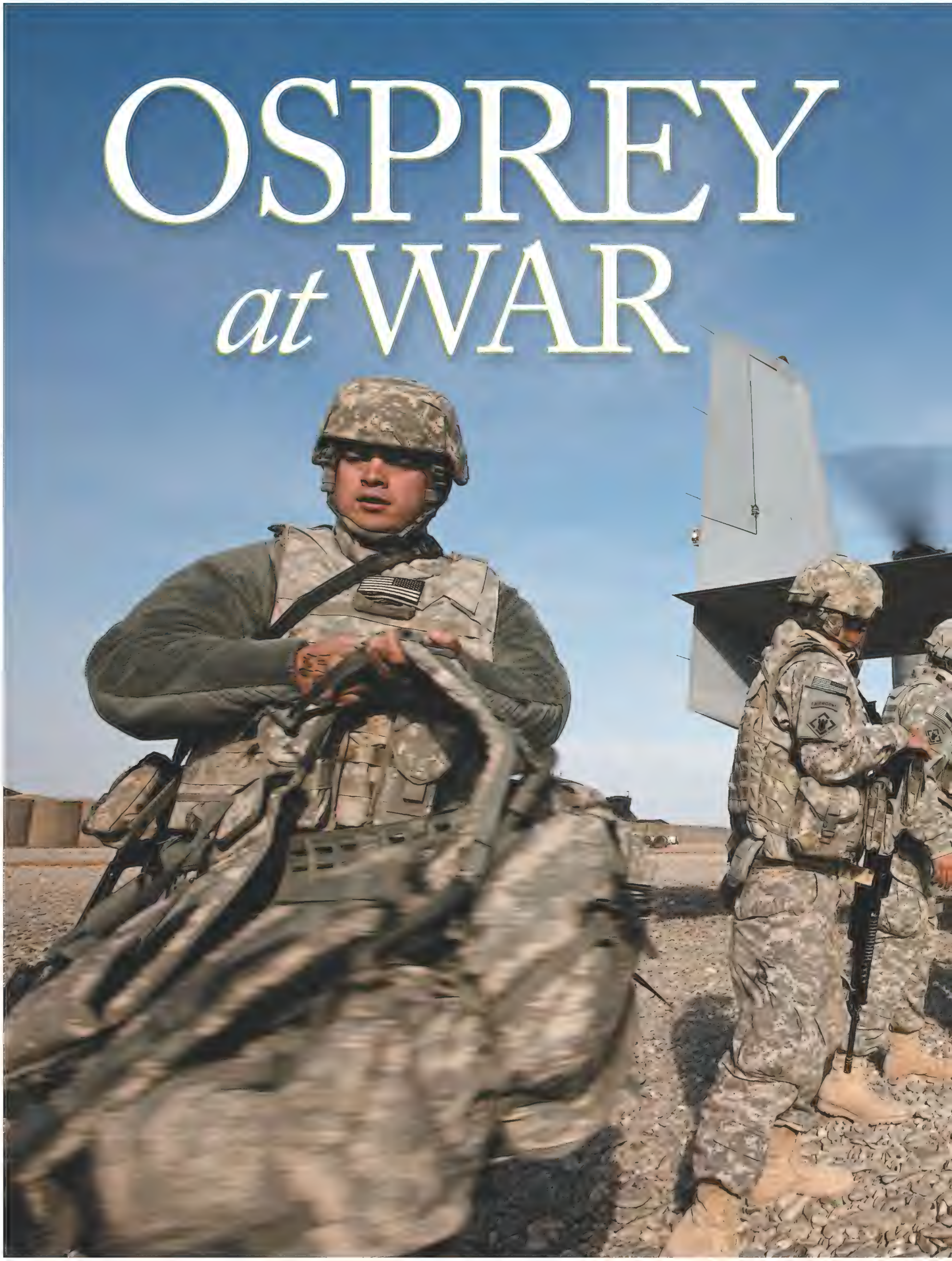
For a small airline, a single forfeiture can be the death knell. But for the airplane, it's a new life. Before the wheels leave the ground, the bank is already re-marketing the airliner. A fresh paint theme, bold new logos, a spruced-up interior, and it's a revenue-making magic carpet once more.

With more than 26,000 airliners in the world, one is always ending up in the hands of a failing carrier. And it's bound to happen eventually—somebody will go deadbeat on the biggest airliner ever built: a 1.2-million-pound, 600-passenger Airbus A380 Superjumbo. Maybe they'll even try to hide it too. Popovich just shrugs at the gargantuan scale of what will inevitably come next. "It might take us a little time to put together a crew," he says, "but we're ready." This is a man with job security.

Nick meets son Zak after the latter's first repo: a Citation 601, reclaimed last year. Below: A 737 from failed Brazilian airline VASP. Getting two VASP aircraft took Kevin Lacey months – long stretches of boredom alternating with moments of high tension.

TOP: COURTESY SAGE-POPOVICH, INC.; RIGHT: BRUNO PEREIRA

OSPREY *at* WAR



CAN THE MV-22 PASS MUSTER IN AFGHANISTAN?

STORY AND PHOTOGRAPHS BY ED DARACK

The Osprey's role in Afghanistan has been mainly assault support: transporting troops and supplies (here, Army soldiers unload gear from an MV-22 at a remote combat outpost).

CAMP BASTION, the British headquarters in Helmand province in the south of Afghanistan, is built in the middle of the desert for a reason. There are no villages nearby. An enemy would have to walk through miles of open and flat desert to attack.

It's a tent city, four miles long and two miles wide, with a field hospital and an airstrip. The runway is short, barely long enough to handle the C-17 cargo aircraft that roar in and out of the base each day. The camp sits adjacent to Camp Leatherneck, headquarters of the 2nd Marine Expeditionary Brigade.

Helicopters crowd Bastion's airfield: CH-53D Sea Stallions, CH-53E Super Stallions, Bell UH-1Y Venoms, and AH-1W Super Cobras. In the rough terrain and roadless expanses of Afghanistan—and over roads hiding improvised explosive devices—helicopters are often the only practical means of transportation for U.S. Marines. Until last November, that is. That's when Camp Bastion became home to the tiltrotor MV-22 Osprey and Marine Medium Tiltrotor Squadron 261 (VMM-261), the first Osprey squadron deployed to Afghanistan.

Just four weeks after arriving, the Ospreys went on the offensive. On December 4, 2009, the MV-22s inserted an 80-person reconnaissance force near the town of Now Zad in northern Helmand. Operation Cobra's Anger was meant to shut down the Taliban's line of communications, and the routes through which their fighters and weapons move.

The Osprey's primary role in Cobra's Anger was insertion: carrying 24 Marines like a bat out of hell to combat. Although it did the job in Now Zad and, more recently, Marja, the MV-22's main work in Afghanistan so far has been assault support, transporting personnel and supplies of all types—from mail to bullets to diesel-engine parts—to a series of austere combat outposts throughout Helmand. That mission had been the task of the CH-53 helicopter. (The Marine Corps is replacing the venerable CH-46 Sea Knight, which doesn't do well in Afghanistan's high elevations, with the MV-22.)

The Osprey is not just a newly fielded aircraft but an entirely new type of aircraft, the first transport in operation that can take off and land vertically like a helicopter, but that offers the speed and range of many fixed-wing aircraft. "When you're going to a place without a runway, you need a rotorcraft. When you're going a *long* way to a place without a runway, you need a tiltrotor," says Lieutenant Colonel Anthony Bianca, VMM-261's commanding officer.

This is only the fifth combat deployment for the Osprey (including three tours in Iraq, and a shipboard deployment), a platform that was certified operational just four years prior to its arrival in Afghanistan. The Osprey is enduring more scrutiny than most new aircraft types, because during its development, four Ospreys had high-profile crashes, including one during an operational evaluation in 2000 in which all four crew members and 15 passengers were killed. Major Timothy Miller, -261's operations officer, says, "For a lot of people, the V-22 is an unknown. There are misconceptions, so you have to do some education up front, and attempt to allay people's concerns."

From his tent office on the flightline at Bastion's airfield, Lieutenant Colonel Ivan Thomas, executive officer of VMM-261, summarizes the Osprey's advantages. It's twice as fast as a CH-46 and can carry double the payload. The Osprey can fly above

The "Raging Bulls" of VMM-261 (above) try to personalize Camp Bastion; Ospreys line up on the camp's runway (left), where several will undergo routine maintenance. The MV-22 has a mission-readiness rate of 80 percent.

the ground threats posed by the enemy in Afghanistan, including small-arms fire and shoulder-launched surface-to-air missiles.

For additional protection, the Osprey's powerful engines allow pilots to launch the aircraft vertically and "corkscrew" to altitude directly above the safety of a base.

The launch is unlike anything else. "It felt like getting shot to the moon," recalls Gunnery Sergeant Steve Morris, who was on the original reconnaissance team inserted into Now Zad. "Your stomach goes to your ankles; it's a really heavy feeling."

This morning I get to feel that sensation for myself, as I ride along on a resupply mission. Once loaded and fueled, two MV-22s taxi onto the main runway. With all diagnostic indicators on the aircraft's multi-function displays in the OK, and with clearance from the tower, our Osprey lifts into the air from a dead standstill, the other from a slow roll. As the aircraft begins its smooth arc forward, one of the pilots asks the crew chief, "Ready to go fast?"

"Roger."

Lieutenant Colonel Bianca, one of the program's longest-serving Osprey pilots (he has 1,600 hours as an MV-22 pilot), says of passengers at this point in their first flight: "Open up the throttles and pull the nose back, and you should *see* the look of incredulity on their faces." With one hand on the thrust control lever and another on the control stick (which in helicopter mode works like a cyclic and in airplane mode like a regular airplane control stick), the pilot rotates the two nacelles forward toward airplane mode, and the aircraft's smooth upward arc is replaced by slight buffeting. With the airspeed indicator parked at 180 knots (the top speeds of the fastest production military helicopters range between 150 and 170 knots), the pilot pulls back on the stick, making a hard-right bank and corkscrewing the Osprey steeply upward. "You can tell when a grunt has flown on the MV-22 before by the way he cinches down the straps and holds on to the shoulder strap that's towards the front of the aircraft," says Bianca. "He knows what kind of acceleration is coming."

And accelerate it does, its powerful engines enabling it to climb at thousands of feet per minute. Once at altitude, the speed indicator pushes up to about 230 knots, although the Osprey can go much

It may be cramped, but an MV-22 can hold 24 troops and their supplies. Staff Sergeant Isaac Schuler, standing, makes sure that the passengers and cargo of the 4th Light Armored Reconnaissance Battalion are secured before takeoff.

On a resupply mission (opposite) Osprey maintainers work beneath spinning rotors. Each morning, crews search the ground for potentially hazardous debris (above), and parts that may have been dropped during routine maintenance.

faster. After just a few minutes of flying, we corkscrew back down, and with a rattle reminiscent of a loud lawnmower engine, the nacelles transition back into helicopter mode, and the craft drops onto a landing zone at a combat outpost near the Helmand River.

As the aircraft approaches the ground, stacks of large container boxes rise into view, then dust flies up. Another container box, this one just eight feet in front of the nose, emerges from the dust. The Osprey smoothly touches down. Marines crammed in the back file out a side door as a forklift pulls out two "tri-walls"—large tote boxes made of triple-layer paperboard—full of supplies. At many outposts, the Osprey's powerful engines create a brownout, a blinding plume of dust. On this landing, the air is relatively clear. Pointing to river rocks that Marines have taken from the Helmand and spread over the landing zone, Major Will Grant explains that the improvised surface has created better visibility for landing here.

Once all passengers and their gear have been stowed, the Osprey again rises straight up into the sky.

THE MARINES OF VMM-261 understand their place in V-22 history. The squadron's experiences, particularly combat deployments, will have far-reaching consequences, and the squadron's suggestions will help determine not only what hardware gets used, but also potential software upgrades.

"We are going to write a whole new chapter in Osprey employment out here," says Colonel George Amland, deputy commander of the 2nd Marine Expeditionary Brigade. He acknowledges the great strides made by the three MV-22 deployments to Iraq, but notes that the two theaters have many differences. As planners at VMM-261 develop a mission that will take the Osprey from Bastion to the Pakistani border, 850 miles round trip, Amland comments on the Osprey's benefits.

"The Osprey can collapse the battlespace, and go into areas that are not suitable for landing a [KC]-130J," he says. And because helicopters are transported to Afghanistan as cargo on a C-5, and the Osprey arrives there under its own power, it can free "a tremendous amount of strategic lift by self-deploying," says Amland.

The squadron has 10 Ospreys, and missions usually run four to six hours, with some lasting as long as eight. Both aviators and ground crew serve either day or night shifts, but as missions change, flights are often extended, and day pilots often "hot seat" with night pilots, meaning the pilots and crew just swap places while the MV-22 refuels, and the aircraft never shuts down. The squadron is preparing for the coming troop surge, and that, along with the regular day-to-day resupply and delivery operations, keeps the Ospreys running round the clock, 18 or 20 hours straight, requiring maintenance crews to perform basic fixes in between "hops" with the proprotors spinning above them.

THE HISTORY OF THE V-22 used to bother Staff Sergeant Brian Freeman. He rejoined the Marine Corps after the September 11, 2001 terrorist attacks, hoping to return to a CH-46 squadron, but his only option was an Osprey unit. "In the beginning, nobody wanted to fly on the Osprey," Freeman says. The 2000 Osprey crash had killed a friend of his from boot camp. "I went into the program not trusting the aircraft, and with the mentality that the MV-22 was going to have to prove itself to me. And through the years, it did." (To date, Freeman has logged more than 1,300 hours in the Osprey,

one of the highest numbers in the V-22 program.)

Freeman is now convinced that the Osprey is safe. "I like that it tells you what's wrong with it," he says. "I like that once you understand how to use the computer system, the multi-function displays, the aircraft will give you information that as a CH-46 guy, you had to know what to smell, what to hear, and really have an intimate knowledge of the aircraft to diagnose. There's really nothing that I dislike about the Osprey. I used to love flying on the CH-46, until I flew the Osprey. There are lots of things I don't miss about the CH-46, because the Osprey's capabilities make that aircraft obsolete."

During scheduled maintenance, all aircraft are scrutinized down to the smallest nut and bolt (proprotor assembly, foreground).

Major Larry Nichols came to the squadron after flying single-seat F/A—18C Hornets. "It's as if a CH-46 and an F-18 had a baby," he says. "I feel like I'm stealing when I fly the Osprey; it is a fantastic aircraft to fly, taking off like a helicopter and the [high] performance of it in aircraft mode."

He does think the cockpit design could be improved, and he also has a minor quibble with the software: "The number of keystrokes to get to certain menus is time-consuming and excessive. There are some real tedious steps to manage certain functions that are significantly simpler and more intuitive in a Hornet, specifically regarding communication and navigation."

Once -261's seven-month tour is complete, another Osprey unit will take its place—and learn from VMM-261's experience. In Afghanistan, for instance, Captain Chris Meixell explains, "Many of us fly the initial leg of the spiral approach a little tighter, as the forward operating bases here are a little smaller than those in Iraq, where the spiral approach was first used for the Osprey."

Maintenance crews are also learning from the new environment. Sergeant Frank Mershon, an avionics technician, typically works 12 to 16 hours a day, seven days a week. (In addition to his primary job, Mershon is an aerial observer, so he often flies to aid a mission.) "Every day is different," he says. "We get certain gripes [problems or parts needing repair], and once we get our gripes, we go out and troubleshoot them." Mershon moved into -261 from a CH-46 squadron. He seems to thrive on the challenges posed by southern Afghanistan's austerity. "The V-22 is definitely more of a challenge, but it definitely makes you think to the next level," he tells me in the squadron's small chow hall, filled with cards and letters

Left: A Marine looks on as ground crew "hot fuel" an idling MV-22. Above: The Osprey has the range for Afghanistan, but is it tough enough?

Visit the Web site to see video from the author's trip.

from squadron members' families. "The -46 was pretty simple, and the Osprey is brand new.... We're experiencing maintenance issues that the Osprey has never experienced before."

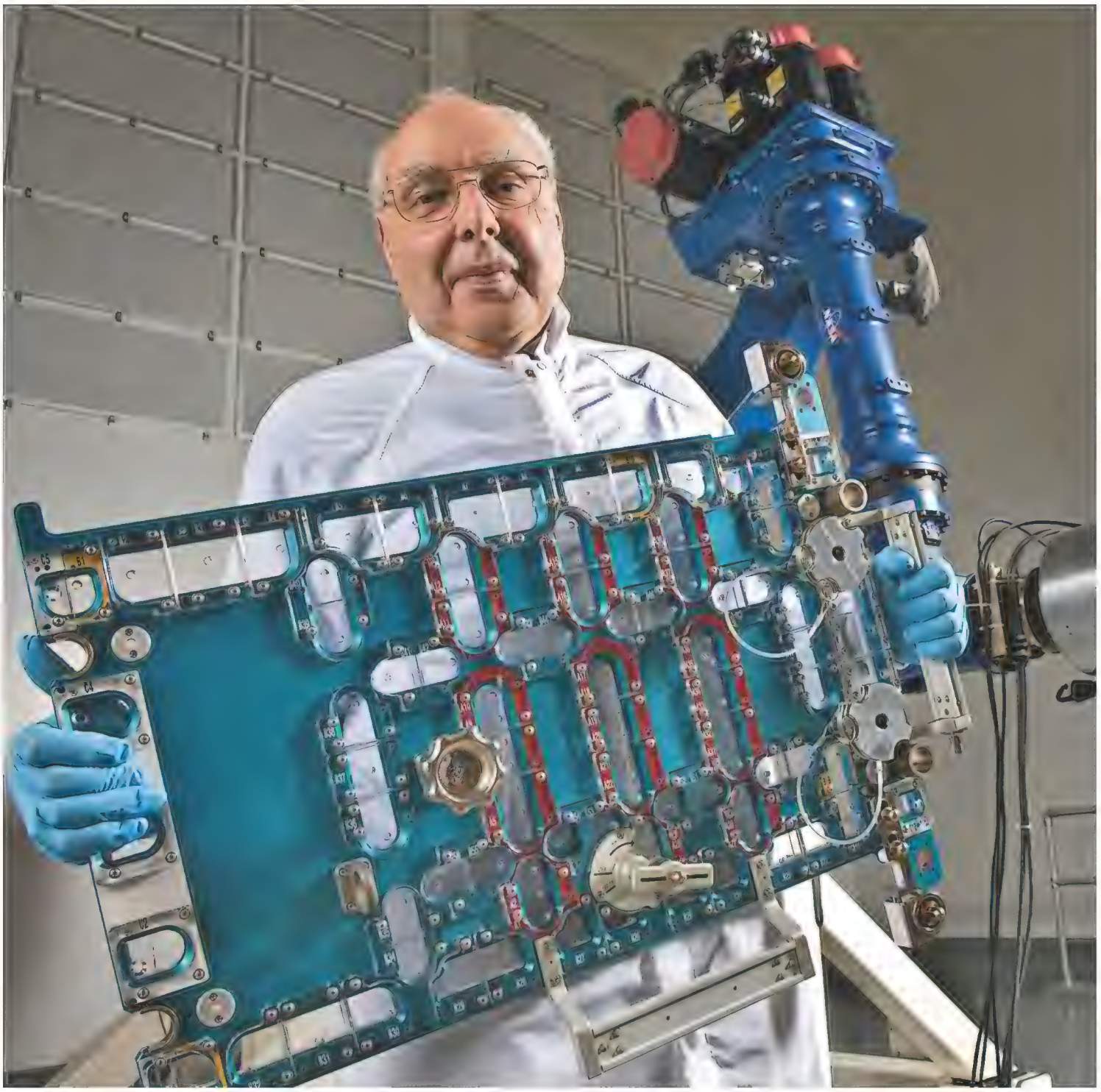
PERHAPS THE MOST powerful endorsement comes not from the Osprey squadron's pilots or maintainers, but from one of its passengers. "The grunts are the proving ground for the Marine Corps. What [the Osprey] does for the grunts is what its true capability is," says Gunnery Sergeant Morris. "Something may look good at the Miramar airshow, but what does it do for the infantry Marines? And that Osprey, in my opinion, closes the gap.... It is a huge push forward for the infantry."

At the end of my stay with VMM-261, I asked to visit a remote outpost on the shores of Helmand River. I'd be traveling by Osprey, but this time as an anonymous passenger, not a media embed given the privilege of sitting in the cockpit jumpseat. With the temperature dipping below freezing, I stood with a small group of Marines and civilians as four CH-53s and two Ospreys idled on the edge of the runway.

When given the word, we hustled up the Osprey's rear ramp, and I wrestled my backpacks onto my lap, crammed so tightly into the aircraft that I could hardly find my seatbelt. When we were all strapped in, the pilots taxied the aircraft onto the runway. By the anticipation on their faces, I could tell that most of the passengers had never flown in an Osprey before. The crew chief made sure everyone knew to hold on; once he'd answered the pilot's question—"Ready to go fast?"—we'd all shift toward the open rear ramp.

As the Osprey began its spiral climb, I felt the same powerful G-forces as everyone else, although I had one advantage: My watch had an altimeter, so I knew when the steep climb would stop.

After making two stops, we reached my destination, a small camp dotted with tents, generators, and a few high antennas for communication. I dragged my gear out of the way of the rotor wash, then watched as the Osprey disappeared, the only visible lights the dim green glow of the pilot's night-vision goggles.



Mr. Fix-It

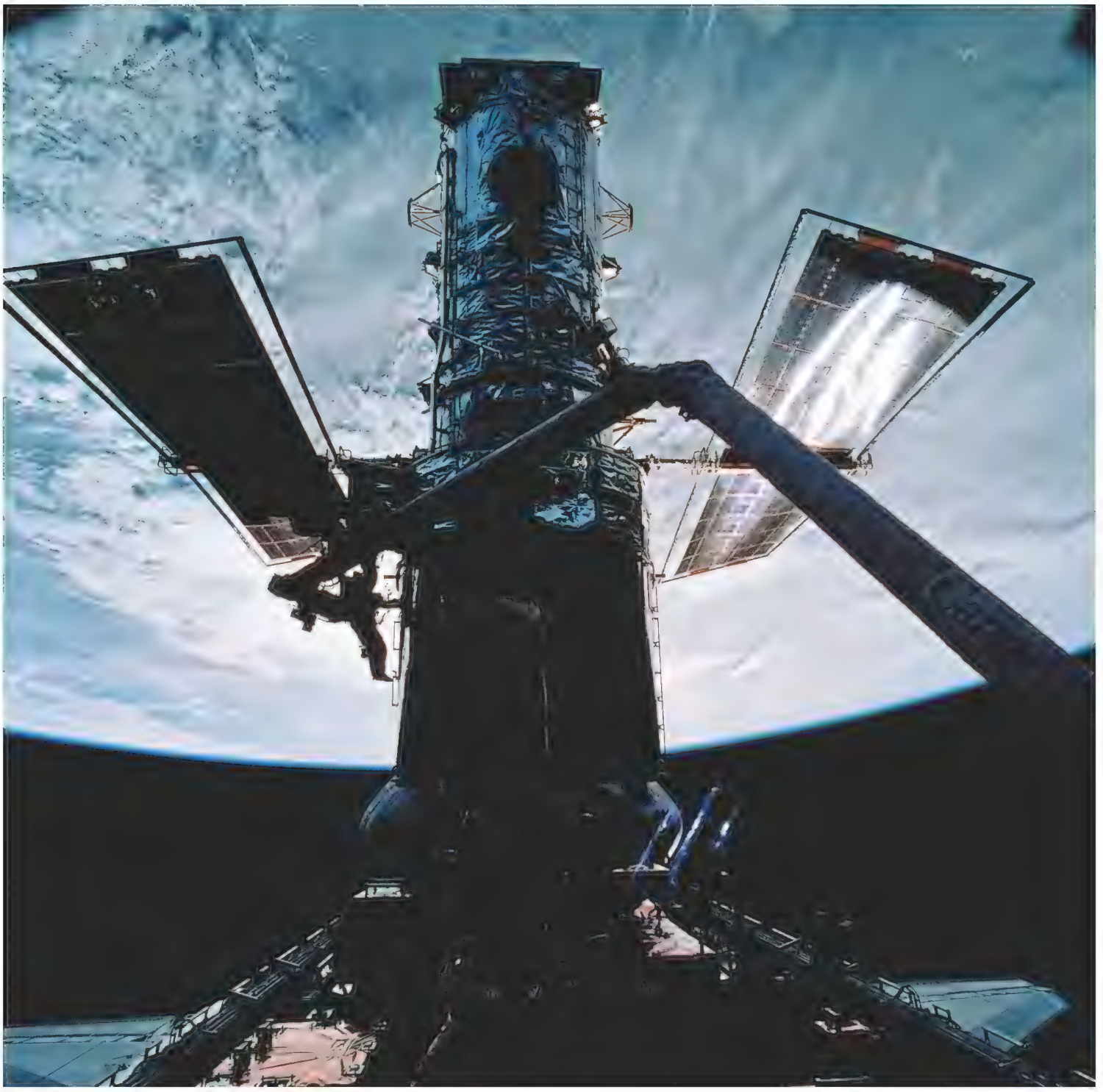
FRANK CEPOLLINA TAKES REPAIR CALLS TO NEW HEIGHTS.

AFTER 20 YEARS IN ORBIT, service calls to the Hubble Space Telescope seem so routine that it's hard to believe they were once considered heroic. But after seven space shuttle astronauts first visited the telescope in 1993 to correct its flawed optics—a mistake that had embarrassed NASA, saddened astronomers, and angered Congress—the shuttle crew and managers at three NASA centers were given a trophy. The National Aeronautic Association cited them for "outstanding leadership, intrepidity, and the renewal of public faith in America's space program."

BY ROBERT ZIMMERMAN

Frank Cepollina wasn't mentioned by name, but his colleagues are quick to give him credit. As head of Hubble servicing at NASA's Goddard Space Flight Center in Greenbelt, Maryland, Cepollina took the lead in planning that first, and still most important, Hubble repair. Cepollina "is one of the most innovative, brilliant guys I've ever worked with," says Jim Crocker, who was then an engineer at the Space Telescope Science Institute, where he designed key elements of the 1993 mission. According to Crocker, if it hadn't been for Cepollina, there likely would have been no fix for Hubble.

CHRISTOPHER GUNN



When astronaut Steve Smith paid a service call to Hubble in 1997, he followed the playbook of Frank Cepollina (opposite, with a tool for holding fasteners).

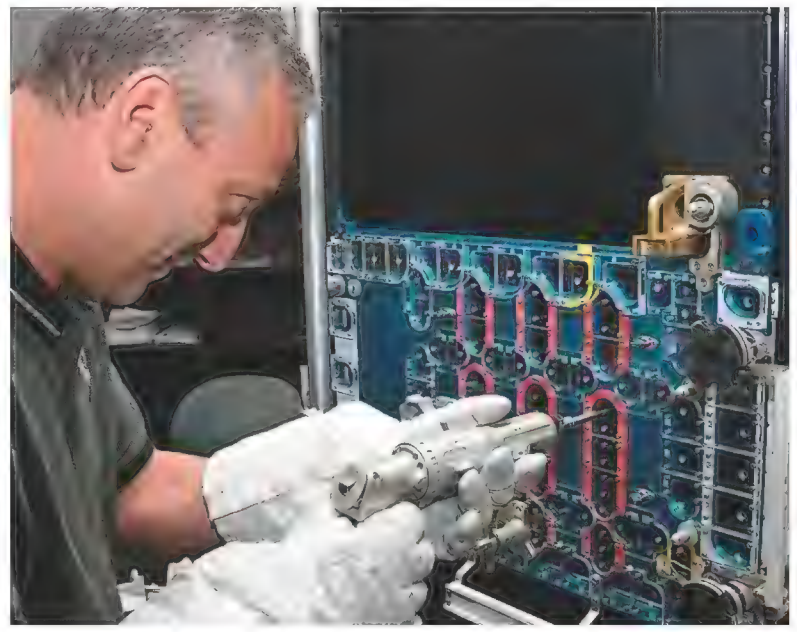
NASA

Cepi, as he is known in the aerospace industry, has for more than 30 years been the world's leading advocate for servicing satellites in orbit. He had his first success when astronauts repaired the Solar Maximum Mission spacecraft in 1984, and for nearly two decades he has overseen service calls to Hubble, among the most complicated space missions ever flown.

With the completion of the space telescope's fifth and final upgrade last year, you would think the 73-year-old Cepollina would be ready to call it quits. Retirement, though, is the furthest thing from his mind. As he hustles around his Goddard lab, showing me various Hubble repair tools his team developed, he describes his plans for the future, including an audacious project to have robots refuel spacecraft in orbit. "My plan is to develop a national capability to repair and maintain satellites, anywhere and in any location in space," he explains.

A cheerful man who can overwhelm you with his enthusiasm, Cepollina was raised on a farm in Alameda, California. His job as a child was to maintain the tractors. "I used to have fun taking things apart and seeing how they worked," he says. In high school, he set his sights on an engineering career. His grandparents, Italian immigrants who believed in hard work and education, were a big influence. "My grandfather always used to tell me, 'You never want to work with your hands.' And my grandmother added: 'You want to go to college, learn a profession!' "

Cepollina earned a bachelor's degree in mechanical engineering from the University of Santa Clara in 1959, got an Army commission, and went to work for the Army Security Agency in Warrenton, Virginia, not far from Washington, D.C. His work brought him into contact with engineers at Goddard, who were building some of the first unmanned space science probes. "This struck me as being more fun," he says. "I thought the people [at Goddard] weren't afraid to try new things, weren't afraid to push new technology." In 1963, he moved to NASA.



NASA/JSC (2)

The only real drama during the 1984 Solar Max rescue mission was capturing the satellite and securing it in the shuttle cargo bay. The repair itself (above) went faster than planned.

In those early days, it wasn't certain that humans could do useful work in space. Not until Buzz Aldrin's Gemini 12 flight in 1966 did an astronaut demonstrate the ability to do detailed technical tasks during a spacewalk. Still, Aldrin needed an enormous amount of training to perform simple exercises such as turning a bolt, connecting plugs, and cutting wires.

Around the same time, Cepollina was moving from one Goddard science project to another. Most were failures. His first NASA mission was the Advanced Orbiting Solar Observatory, which was cancelled in 1965 before reaching the launch pad. Then came the Orbiting Astronomical Observatory program, which was planned as a series of four space telescopes. The first OAO failed shortly after launch, and the third never reached orbit because its rocket shroud failed to jettison.

That wasn't uncommon in the 1960s. Approximately 30 percent of NASA spacecraft failed within 10 days of launch. "Some would go in the drink, some the boosters would blow up," Cepollina remembers. "Some would go up, get turned on for a few hours, and *then* die."

In the early 1970s, George Low, NASA deputy administrator and one of Apollo's guiding lights, was pushing the agency to make its spacecraft more reliable and less expensive. Cepollina's boss, Joseph Purcell, put together an ad hoc committee to look into the problem. The committee suggested that if spacecraft design was standardized and satellites were built with modular components, NASA could save time and money.

With Purcell's enthusiastic support, Cepollina took the notion and expanded it, conceiving the idea of designing separate modules for attitude control, power, data handling, and the like—functions required on every spacecraft. These plug-and-play units could be installed on any satellite, and they would be easy to replace.

Cepollina's Multimission Modular Spacecraft (MMS) program built half a dozen science satellites in the 1970s and 1980s, including the Solar Maximum Mission spacecraft to study the sun, Landsats 4 and 5, the Upper Atmosphere Research Satellite, and the Extreme Ultraviolet Explorer.

To most people, the modular spacecraft program made engineering and economic sense. But for NASA managers in charge of new research satellites, the modular approach limited their flexibility and stole some of their glory. "Their whole goal was to develop and build a new spacecraft, using the newest technology," explains Joe Rothenberg, who was then working for Grumman but later became Cepollina's boss at Goddard. "Many project managers were always fighting with him."

The resistance didn't faze Cepollina. "You keep your nose down, keep driving the frigging car," he says. He worked hard, and demanded the same from his employees. "If you didn't do a good job you wouldn't be working long on Cepi's projects," remembers Elmer Travis, a former Goddard engineering branch chief who's now retired. Cepollina "was not a typical government employer. He came to work at 7 a.m. and would be there until 10 at night. Then when he went home he never stopped working. He would call me at 11 o'clock at night, wanting some help on a problem."

David Martin, who worked for Cepollina from 1988 to 1994, says: "Frank was and remains one of my heroes. Everybody who works at NASA should work for him for a while." But, he adds, "To be honest, you can burn out."

As the MMS program was getting under way in the early 1970s, the space shuttle program was also gearing up, and the two seemed perfectly matched. "We realized we could take advantage of the shuttle's two-way capability," Cepollina recalls. If a satellite component failed, the shuttle could return the spacecraft to Earth, where it would be a simple matter to swap modules. From there it wasn't a big leap to in-orbit servicing. Why bring the satellite back when the replacement could easily be done by a spacewalking astronaut?

Amazingly, NASA managers were not interested in the idea at first. Goddard's focus was on reducing the cost of satellites and increasing their reliability, and there was no money for servicing missions. Then Solar Max failed. The mission had been launched in 1980 as the first of Cepollina's modular spacecraft; its job was to observe the sun at the peak of its 11-year cycle, and it had been designed to be retrieved by the shuttle.

Only nine months after the satellite was launched, however, three fuses in its attitude control system module failed. Shortly

Opposite: In March 2005, in an underwater tank at the University of Maryland, a mechanized repairman practiced Hubble servicing — in vain. Humans got the call instead.

NASA/HUMAN SPACEFLIGHT

Fixing Hubble required lots of bolting and unbolting by astronaut Mike Massimino, shown training for the task (opposite) and working on the telescope in space in 2009 (on the left).

after that, a coronagraph-polarimeter designed to study the sun's corona suffered an electrical failure. Though the spacecraft had been built with plug-and-play subsystems, NASA management was uninterested in a repair mission. Some feared it would be a waste of money: What if something else on the spacecraft failed soon after the repair? More importantly, there was no money for a fix; paying to repair Solar Max would have delayed or canceled some other project.

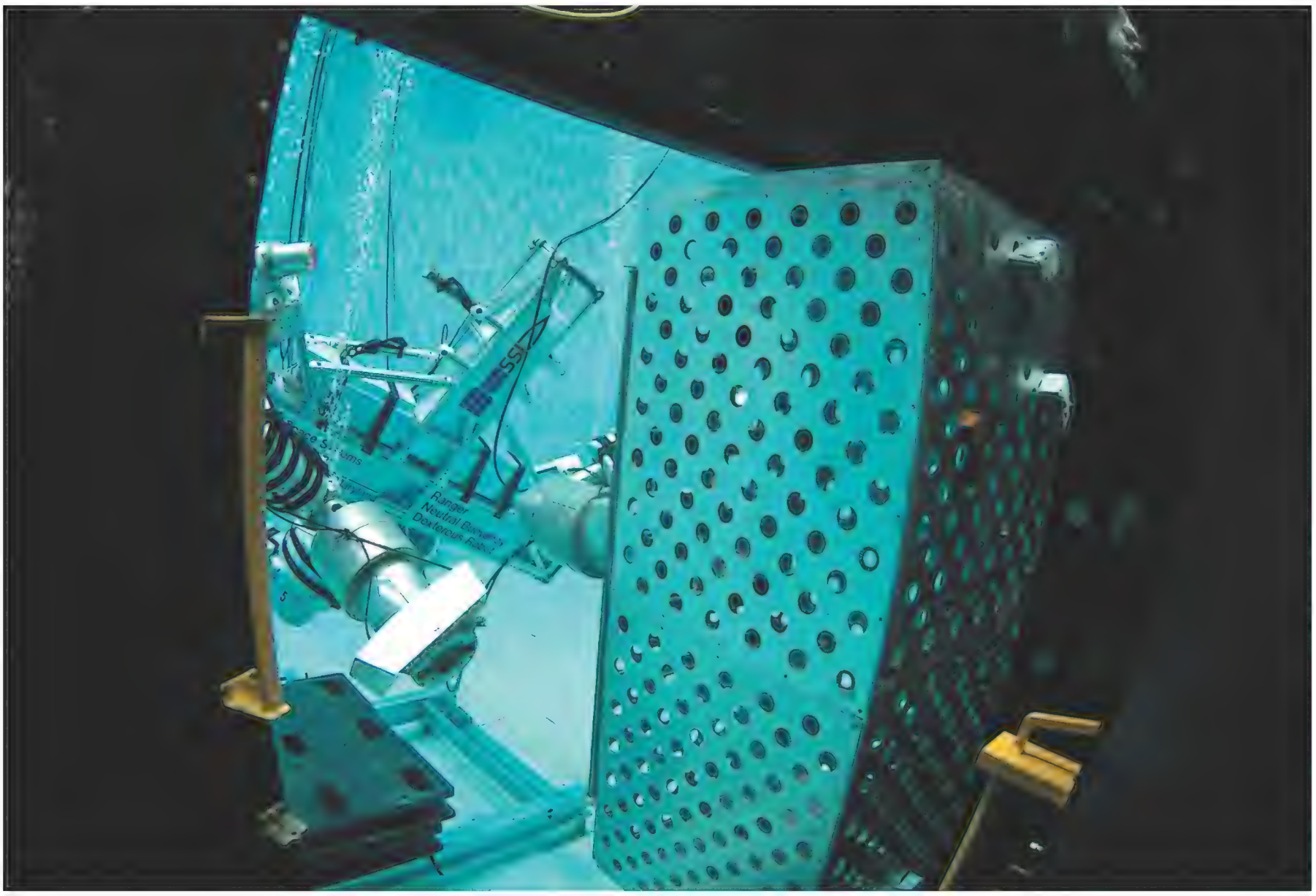
To Cepollina, *not* doing the repair when it was feasible was unacceptable. He began calling reporters, letting them know that the spacecraft's repair would be a trivial matter. "He was not beyond going to the press," remembers Rothenberg. "His ideas would be in the papers before anybody in the NASA management chain even had a chance to approve it."

The outspokenness got him in trouble. "I can't tell you the number of times his boss, including me, had him on the carpet, telling him to cease and desist," adds Rothenberg. "He'd walk out of the room dejected, go home to sleep it off, and then return the next day as if he never heard what his boss said."

Cepollina knew that if he could marshal public and Congressional opinion without causing harm to his superiors, they would eventually go along. Sure enough, NASA headquarters finally approved the repair mission, with Cepollina in charge.

He remembers it as the most terrifying time in his career. The future of in-space servicing, an idea he had promoted for years, hinged on this one flight. And immediately after space shuttle *Challenger* rendezvoused with Solar Max on April 8, 1984, the plan started to unravel. Astronaut George "Pinky" Nelson donned a Manned Maneuvering Unit backpack and flew from the shuttle to the satellite, but was unable to capture Solar Max with a specially designed piece of equipment (it turned out later that a grommet on the satellite—which didn't appear in blueprints—blocked the docking mechanism).

After three attempts, Nelson succeeded only in setting the spacecraft tumbling. It took a series of hastily prepared software uploads by the ground, combined with a bit of luck when the



UNIVERSITY OF MARYLAND SPACE SYSTEMS LABORATORY

NASA/HUMAN SPACEFLIGHT

EDWARD CHEUNG

Cepollina (left, gesturing) talked his bosses into funding an orbital experiment with the two-armed Dextre robot (above), which will be used to demonstrate orbital refueling.

nearly dead spacecraft drifted into sunlight just long enough—10 minutes—to charge its batteries, to stabilize the spacecraft so that the *Challenger* astronauts could grab it with the shuttle's robot arm and haul it into the cargo bay. Finally back on script, Nelson and crewmate James "Ox" Van Hoften breezed through the repair. "They had to do two days' worth of stuff in one day, and they finished it all," remembers Barbara Scott, who was the payload operations engineer for the repair mission and is now the Hubble Flight Software manager at Goddard. As a result, Solar Max operated for another five years, recording more than 12,500 solar flares. Just as significantly, the failed attitude control module was returned to the ground, refurbished, and installed on another spacecraft, the Upper Atmosphere Research Satellite. That spacecraft was launched in 1991, and operated in orbit for 14 years. "Second-hand Rose," Cepollina quips.

The Solar Max repair gave NASA confidence in its plan to send astronauts to Hubble periodically to replace cameras and other scientific instruments with more capable ones, just like an observatory on the ground. For the first Hubble service mission—which also corrected the telescope's out-of-focus mirror—the Goddard team came up with procedures for replacing three failed gyroscopes, two electronic control units, and eight fuses.

Later missions have replaced Hubble's instruments and gyroscopes several times over, installed a more powerful set of solar panels to replace the ones brought up in 1993, replaced the telescope's computer and batteries, and repaired damaged insulation. After five upgrades, Hubble no longer carries any of the scientific instruments it had at its 1990 launch.

Despite the unqualified successes, the final servicing mission almost didn't happen. After space shuttle *Columbia* and its crew were lost in 2003, NASA cancelled all flights to destinations other than the International Space Station, for fear that if the vehicle were damaged, the crew would be unable to return to Earth. With astronauts barred from visiting Hubble, Cepollina pushed for a daring alternative: He would send a robot to repair the telescope, using procedures and tools honed by more than a decade of planning astronaut repair missions.

In the interest of time, the Goddard team chose an existing robot for the job: the Canadian Special Purpose Dexterous Manipulator, which was already built and waiting to be launched to the space station (where it's now known as Dextre). Starting in 2004, Cepollina's team worked feverishly in Maryland and in

Canada to prove that Dextre, using tools attached to the end of its robot arm, could accomplish tasks normally done by astronauts: replacing two large science instruments, a fine-guidance sensor, gyroscopes, and batteries. The work involved lots of unbolting and bolting, as well as numerous electrical and data connections. In practice sessions using high-fidelity Hubble mockups, Dextre showed that it could handle the work. The team even simulated the two-second time delay that skeptics thought would be a severe handicap when the robot was tele-operated from the ground. Not a problem.

Once again Cepollina worked the PR channels, appealing directly to Congress and the media, pushing a robotic mission. This time, though, the answer was no. NASA asked the National Academy of Sciences to review its plans for Hubble servicing, and the verdict, rendered in December 2004, was that a robot-only mission would push technology too far, too fast. It wasn't impossible, said the academy, but there were too many unknowns—including whether an automated spacecraft could rendezvous and dock safely with Hubble—to pull off a complex robot mission with just three years of planning. NASA went with astronauts instead.

"I do think they [the academy] were unduly conservative," says David Akin, a space roboticist at the University of Maryland who helped Cepollina's team with underwater testing of their procedures. But Cepollina accepted the finding and turned immediately to planning the astronaut repair, while keeping the robot option on the back burner. The tools and procedures developed for the robot mission made the astronaut service call far more efficient, he says. "It allowed [the astronaut crews] to do seven or eight days of work in five." And during the last servicing flight his team was able to conduct experiments, in parallel with the astronaut repairs, to evaluate capabilities such as robot vision. "We never stopped moving [to develop robotic servicing]."

Now, he says, "I'm proposing to take the next step." Congress has given him $70 million—a large amount in the field of space robotics—for a space station experiment to demonstrate robotic satellite refueling. Ground tests are under way at Goddard, and by the end of this year Cepollina plans to use Dextre to demonstrate all the steps of refueling on a hardware mockup equipped with standard satellite ground refueling valves, connections, and insulation blankets. The test goes by the name R2D2, for Robotic Re-Fueling Dexterous Demonstration.

Cepollina concedes that at the time of the academy study, certain critical steps in robot servicing had not been demonstrated in space. But many of them have been since. The Defense Department/NASA Orbital Express mission, flown in 2007, showed that one satellite could dock with another automatically, use a robot arm to change the second satellite's modular components, and transfer fuel. A low-cost Air Force satellite called XSS-11 was able to maneuver precisely around other spacecraft, and Dextre was installed on the space station in 2008.

"Orbital Express did all the things the academy said would be too difficult and risky," says Cepollina. As a result of these projects, space robotics has convinced some former skeptics. "The technology has not advanced that much [since the academy study]," says Akin. "But the perception of it has changed tremendously."

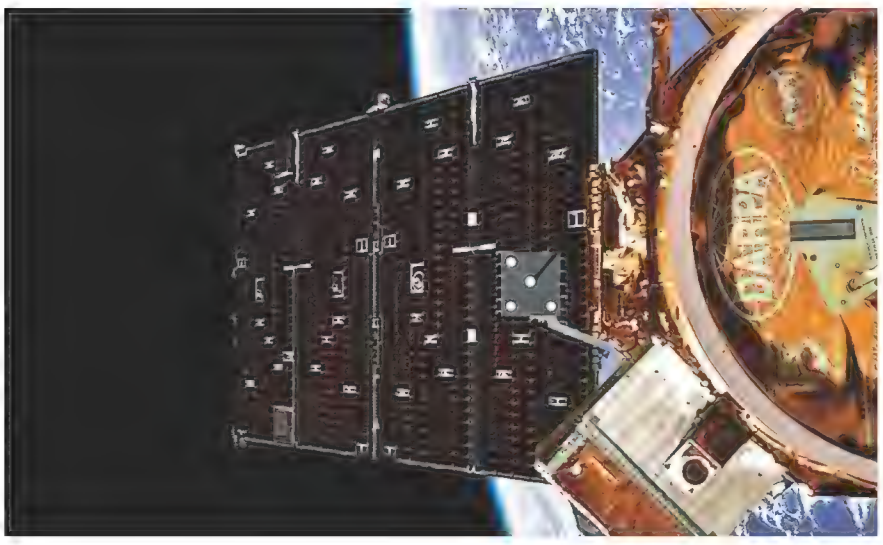
If the space station test goes well, Cepollina hopes to work out a deal to refuel several NASA and military satellites that are still in perfect working order except for lack of fuel. He envisions those missions jump-starting a commercial business to refuel and extend the lives of communications satellites that produce billions of dollars in revenue. "Once [refueling is demonstrated], the whole system could be turned over to commercial contractors," says Cepollina.

Akin agrees, although he thinks that to be affordable, an operational system would probably have to use a smaller, lighter robot than Dextre. And, he says, "I give Cepi full props" for taking the lead in proving the feasibility of robotic servicing.

Cepollina seems worried only by the prospect of competition. A Swedish company, Orbital Satellite Services, is developing a spacecraft tug, based on the European SMART-1 moon probe, to extend the lives of commercial communications satellites by serving as a new propulsion system. It's a simpler and likely cheaper alternative to refueling, with no capability (at least initially) to handle more complicated repairs. Dennis Wingo, a principal in Orbital Satellite Services who has been working on plans for commercial satellite servicing for years, says the company already has one "hard, signed contract," although it has yet to nail down the financing it needs for a refueling mission.

But Cepollina has decades of experience, a dedicated team, and now, approval and funding for a test on the space station. If this turns into a race, you might not want to bet against him.

The success of Orbital Express (below) came too late for Goddard engineers (right, with their test rig) to convince skeptics that a robot could fix Hubble in the near term.



BOEING/ COURTESY DARPA

EDWARD CHEUNG

How Good Is Your Airline?

TWO PROFESSORS ANALYZE THE STATS.

BY CRAIG MELLOW

IS JETBLUE A BETTER airline than Delta or American? Travel writers and road warriors noisily debate such questions. But 19 years ago, two professors from Wichita State University in Kansas devised a standard measure to provide some answers. It's called the Airline Quality Rating.

Aviation technology professor Brent Bowen and business professor Dean Headley still compile the Rating annually and release it in early April to a voracious public. Their first report might have vanished into academic obscurity but for an ABC News stringer who got wind of it and pitched a story to "Good Morning America." The professors were flown off to New York, and a media sensation launched. Bowen has moved on to Purdue University, while Headley remains in Wichita, but the partnership is intact.

Where they once burned up fax machines coping with an unexpected flood of publicity, they now have a Web site, *www.aqr.aero*, to deal with 40,000 downloads and more than a million hits in the first few days after the Rating's release, to judge by last year's response. The professors, who still draw academic salaries, have never made a dime off the project. And yes, in case you were wondering, JetBlue consistently trounces the legacy carriers. The Queens, New York-based airline ranked as one of America's top three for quality in the last six years. In the 2009 report, American came in ninth out of 17; United Airlines, 11th; and Delta, 12th.

The bottom of the airline quality list is occupied by regional carriers that feed into national hubs and are typically owned by one of the large, recognized airlines. Says Headley, "The smaller airplanes that regionals fly are prone to weight and balance issues, forcing flight crews to delay takeoffs as they shift customers forward or aft in the cabin." And at outlying airports, such jobs as luggage handlers and other ground crew are often shared among carriers, a situation that can create chaos when many flights arrive at once. Atlantic Southeast Airlines, a Delta property, has logged four straight last-place finishes.

The professors scrutinize airlines that carry more than one percent of U.S. traffic. They avoid international carriers, as data is reported differently across governments or isn't available. Their survey was limited to nine or 10 airlines until 2002, and peaked at 18 in 2006. In recent rankings, newer, smaller entrants dominate. JetBlue and AirTran Airways are joined in the quality circle by Hawaiian and Southwest Airlines and, with a somewhat choppier record, Alaska Airlines. Old-line giants group in the middle of the ranking, with some exceptions: Northwest Airlines marched from next to last in 2002 to fourth in 2007 and 2008.

Has airline quality improved or deteriorated since 1991? Dean Headley's answer will disappoint both optimists and grouches: Neither. Quality runs in cycles. It declines as airlines and airports get busier, and vice versa. The worst year on record, 2007, came right before the bubble econ-

omy burst. The post-9/11 decrease in passengers greatly improved airline quality.

Headley's prescription for the ups and downs is an overhaul of air traffic control. "It's the weakest link in a fairly well-developed system," he says of the 1950s technology. NextGen, the GPS-run air traffic control system of the future, can't get here soon enough, he adds. It is supposed to become widely operational by 2018, and is expected to help airports launch and land more airplanes per hour, allow airlines to fly more direct routes, and enable airliners to fly closer to one another more safely. All of this should help reduce delays and improve fuel economy, and thereby boost overall performance of most airlines. Airport infrastructure will need to improve as well: We'll need more runways, and more airports.

Bowen and Headley take zero interest in flight attendants' smiles or the crispness of the rolls (on those flights that still offer rolls). Headley doesn't even enjoy air travel. "I prefer not to fly if I have a choice," he says. "I'm kind of a big guy, and I don't always fit in the seats." The professors track four categories: late arrivals; overbooking, which leads to bumped passengers; mishandled luggage; and complaints from passengers irate enough to formally address the government. The Rating's data is publicly available from the U.S. Department of Transportation and the Bureau of Transportation Statistics. "We get very little criticism from the airlines," says Bowen. "They monitor the same things. If our formula wasn't putting it out accurately, they'd be the first ones to let the world know."

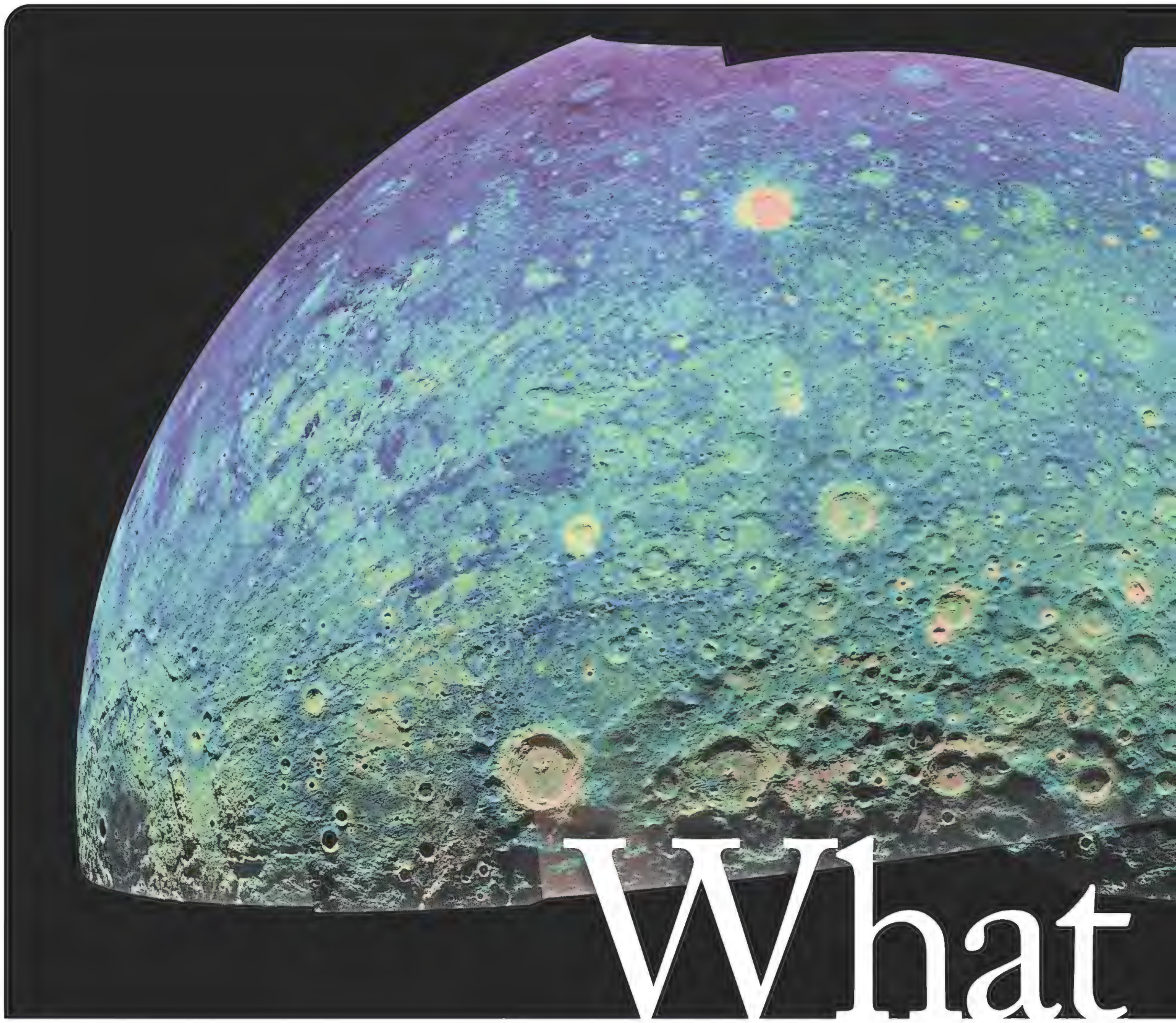
Consumer Reports, J.D. Power and Associates, and other rivals rely on "a more perceptual base" that lets subjectivity creep in, Headley says.

Does the Rating have a dollars-and-cents impact on the airlines? That's hard to gauge. "Business travelers bring in maybe 80 percent of the revenue, and their companies have block agreements with one airline or another," says Helane Becker, an analyst who follows the industry at Jesup & Lamont, an investment house in New York. "Leisure travelers just look for cost and convenience." A top finish is a source of pride nonetheless. When AirTran took first place in 2007, the company suspended operations for 15 minutes at the home airport in Atlanta and called employees onto the tarmac to salute one another. At AirTran gates across the U.S., banners were hung proclaiming the news.

For a carrier wanting that sort of pride, Headley says, everyone from the top executive to the ground crew must commit to the customer. And, he adds, nothing enrages passengers more than a shrug of no-information when they're pinned at an airport gate or on a taxiway. "I flew home last Sunday," he says, "and it was 40 minutes past departure time before they made any announcements. That might make people walk away from an airline."

Bowen and Headley will announce the 2009 results on April 12 at the National Press Club in Washington, D.C.

PHOTO-ILLUSTRATION BY THEO; PHOTO SOURCES: COURTESY JET BLUE, DELTA AND AMERICAN AIRLINES



What

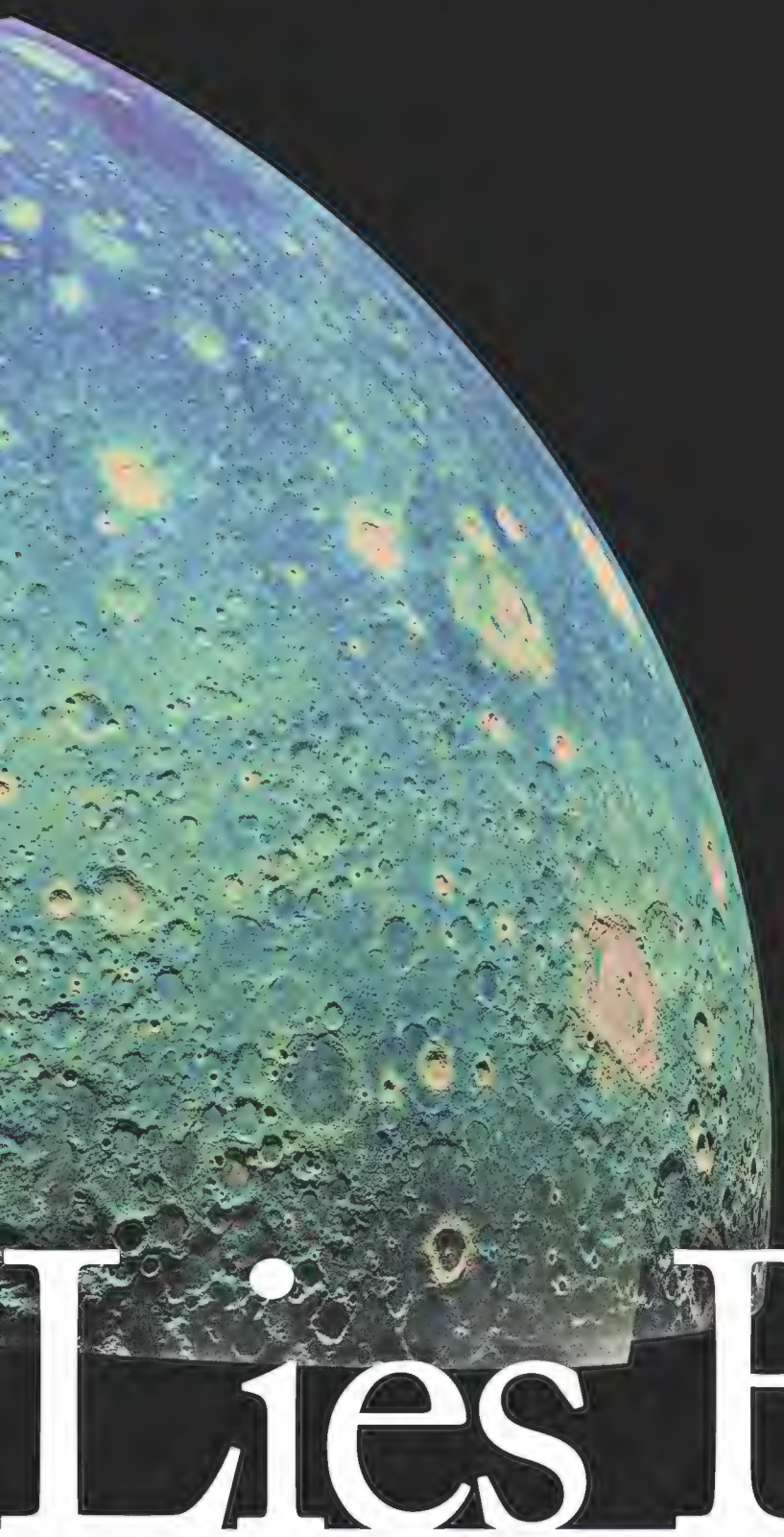
SIX BRIEF VISITS by the astronauts weren't enough. With the surface area of Africa and Australia combined, says geophysicist Bruce Campbell, Earth's moon still has a lot more to tell us.

More than three billion years of the solar system's history lies there, from an ancient era of heavy asteroid bombardment to the thump of pebble- and grain-size meteorites today. Earth's impact record is largely erased by erosion and plate tectonics, or buried by vegetation and oceans. But the moon's is merely obscured by a layer of fine dust. Campbell is unveiling that hidden record.

For peering beneath lunar soil, optical telescopes are useless, because wavelengths of visible light bounce off the surface. So Campbell, who works at the National Air and Space Museum's Center for Earth and Planetary Studies, uses Puerto Rico's Arecibo radio telescope—the world's largest—as a radar gun.

"Arecibo's two-million-watt transmitter can hit the moons of Saturn and pick up the echo," Campbell says. That 1.6-billion-mile round trip requires a few hours. By contrast, Earth's moon is just 240,000 miles away. "You can't shift the receivers at Arecibo in the two and a half seconds before the echo returns to Earth," says Campbell. So he uses the Green Bank radio telescope in West Virginia as his receiver, to avoid the physical problem of not being able to use both the transmitters and receivers at Arecibo. "That gives us lots of flexibility," says Campbell, "and puts more power on the moon from Arecibo." With advances in computing, Campbell has been able to fine-tune the resolution down to about 65 feet per pixel.

Campbell is making lunar maps from these images for two reasons. The first is to understand the moon's fundamental geology, which illuminates how the solar system evolved. The second is to gather data about the lunar surface and subsurface for future explorers, robotic and human. Though recent efforts to return astronauts to the moon have been put on hold, NASA may one day use the maps, along with data from ultraviolet to infrared reflected light, to set up an outpost near deposits that could supply raw materials like iron or titanium, and feedstocks for oxygen and perhaps water.



You don't have to go to the moon to find out what it's made of.

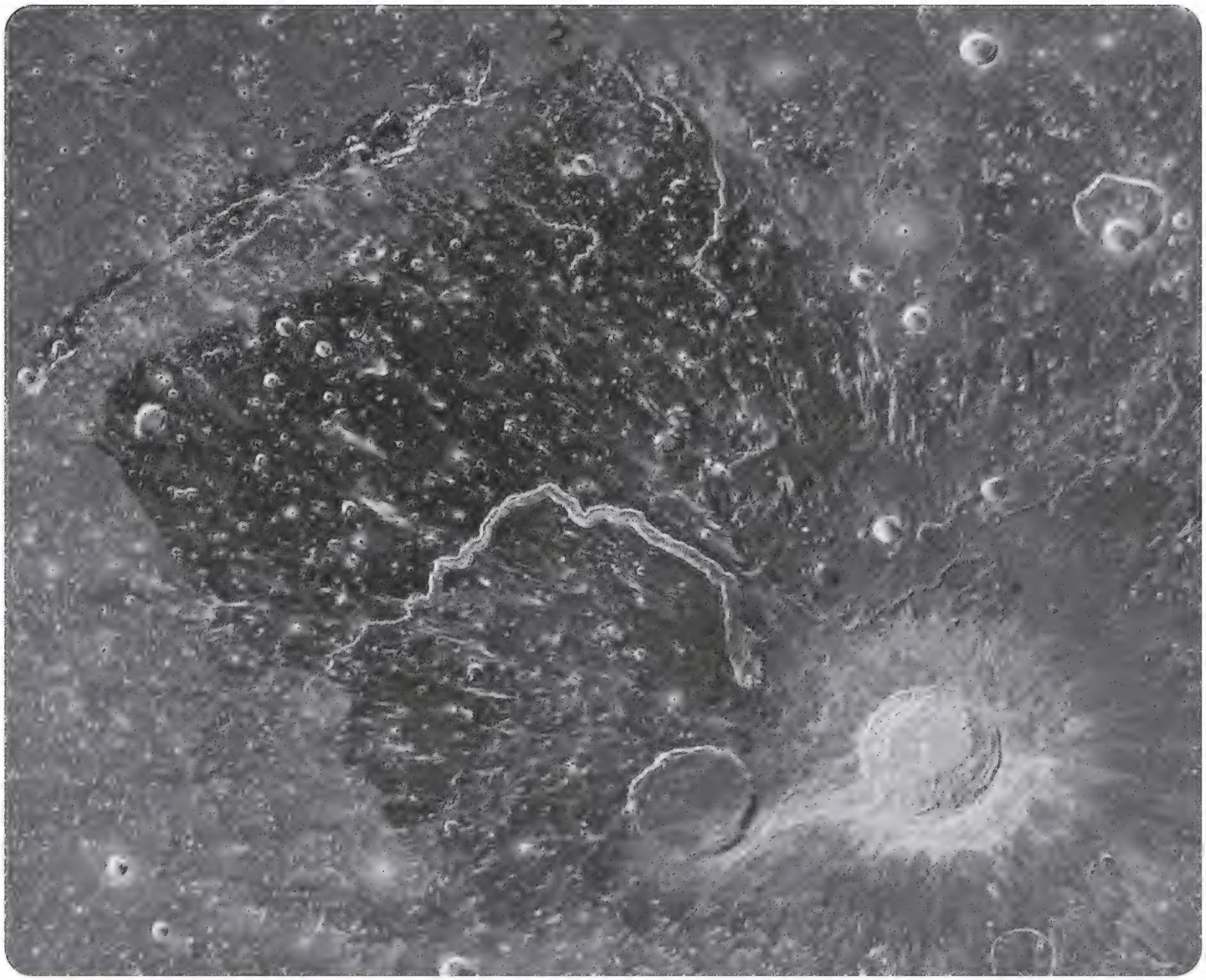
BY MICHAEL KLESIUS

Lies Beneath

Rainbow Moon

The color-coded mosaic shown above is oriented as if the viewer were hovering directly above the lunar South Pole, which lies at the bottom center. In some areas of the surface, the 70-centimeter wavelength penetrates up to 100 feet, "so we are 'seeing' geologic features that occur over that depth range," says Campbell. Greenish hues in the hilly region to the left of the South Pole indicate rocks thrown from the large, multi-ringed crater at far left called the Orientale Basin. Pink and purple hues at the top are transitions to the large, flat mare, or seas, of basalts formed by volcanic activity several billion years ago. Oranges and reds represent a high proportion of fragmented and jumbled rocks in the upper 30 feet of the soil, particularly that in the bottom of the 63-mile-wide Tycho Crater, at upper left center, one of the moon's most recognizable impact craters. "These crater floors retain very crackly lava-like deposits," says Campbell, which do not show up in optical images. Tycho, named for the 16th century Danish astronomer Tycho Brahe, dates to 108 million years ago. Its high albedo, or contrast, with the surrounding moonscape, and the sharp definition in its crater rim indicate that it is one of the moon's youngest large craters. In optical photos its reflective rays of ejecta extend for hundreds of miles in all directions, but radar peers through them. Tycho is hardly the most recent of all the moon's craters. Says Campbell, "There were small craters formed on the moon yesterday." But Tycho, several times deeper than Arizona's Grand Canyon, is a portal through the lunar crust to a time just after the solar system's most massive impact crater, the South Pole-Aitken Basin, was formed on the lunar far side (the South Pole lies on the huge crater's rim). South Pole-Aitken preceded all other detectable impacts on the moon and hurled so much debris, some of it city-block-size chunks, that it coated large areas of the surface. Relatively young craters like Tycho bore down to that ancient bedrock. Over the last few years, with help from post-doctoral fellow Lynn Carter at the Museum, Don Campbell (no relation) at Cornell University, John Chandler at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, and staff

SMITHSONIAN/CORNELL/ARECIBO-NAIC/GBT-NRAO



BOTTOM: NRAO; TOP: SMITHSONIAN/CORNELL/ARECIBO-NAIC/GBT-NRAO

The Green Bank radio telescope in West Virginia, a football field in diameter, is the world's largest steerable dish.

at the two telescopes, Campbell has produced a whole new mosaic of the moon's Earth-facing side. (The far side cannot be mapped from Earth.)

Resourceful Plateau

Radar pulls the veil from the 125-mile-square Aristarchus Plateau, named for the third-century B.C. Greek astronomer. The plateau is an island of lunar crust, uplifted by the impact of an asteroid about 3.85 billion years ago. "We're fuzzy on the ages," says Campbell, "because we have firm dates only from the Apollo samples." Those samples, dated with a method that spans billions of years, provide the dates that have yielded our present-day understanding of the inner solar system's geologic history. More than three billion years ago, the plateau's volcanic deposits spewed from the "cobra head," Campbell says, at the top of the rille called the Vallis Schröteri, which cuts a right angle in the plateau. Fallout cooled into micron-size beads that piled up as glass or fine-grained ash up to 100 feet deep, like icing on a cake. The bright crater at lower right, also named Aristarchus, measures 25 miles across and was born of an impact within the last billion years. The mile-high plateau is frequently suggested as a locale for a permanent outpost where humans could mine its iron and other deposits. While Campbell's images don't show the actual chemical content of the soil, his radar signals scatter in ways that are affected by its iron and titanium content. "So the main thing the radar shows you is how clean the deposits are," says Campbell. "Ejecta streaks on the plateau in the radar image result from baseball-size rocks thrown out by the impact event that created the Aristarchus Crater, which are not as visible in the optical images because they are often buried in the volcanic material. The streaks tell you about the resource potential. You want to pick a radar-dark spot where you'll have clean, fine-grained material to excavate. So it's a good safety check on an optical image."

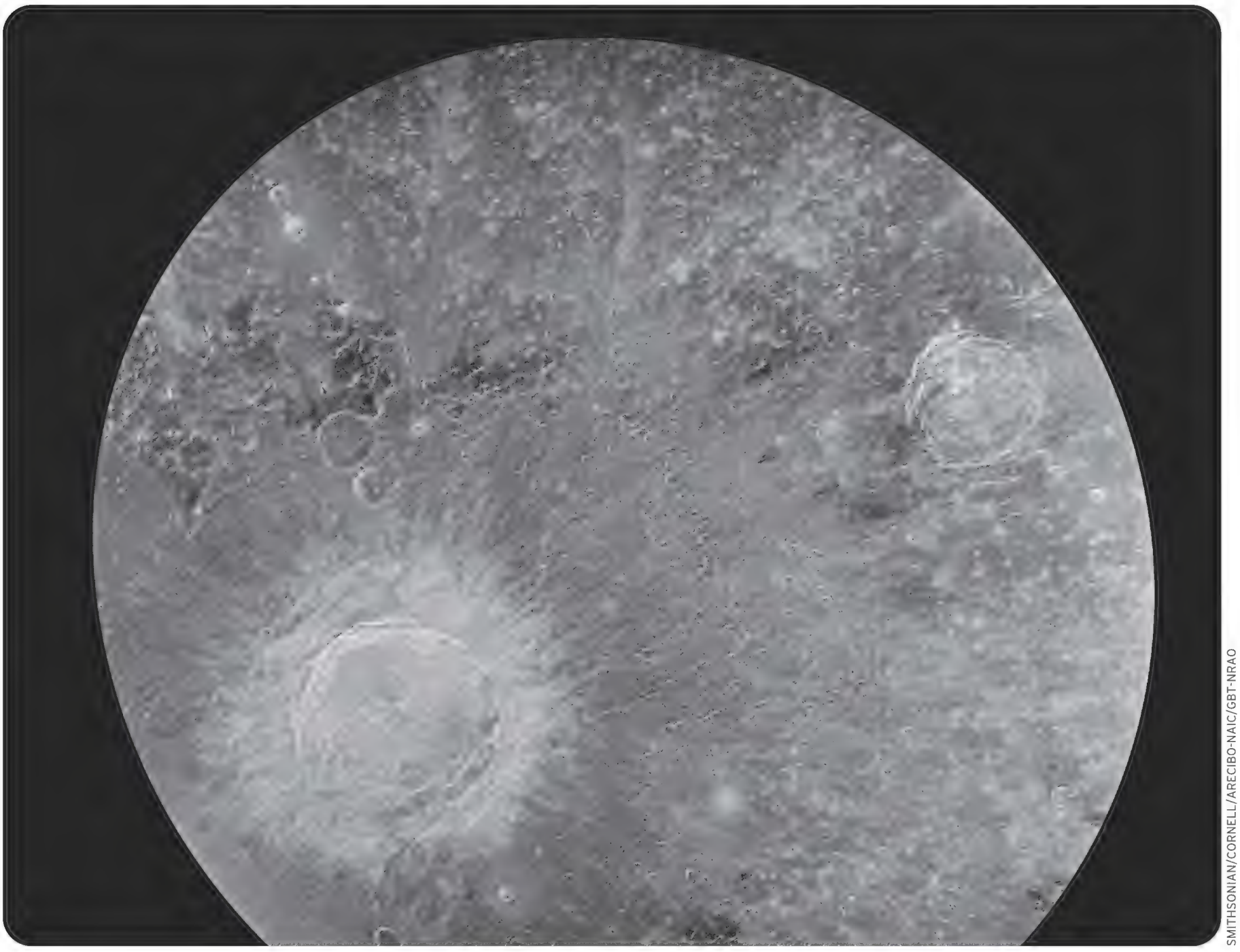
Elusive Landing Site

About 800 million years ago, an asteroid moving three to six miles a second created Copernicus Crater, the bright, 66-mile-diameter crater below, left, named for the 15th century Polish astronomer credited with the heliocentric theory of the solar system. When Campbell pulses Copernicus with the Arecibo telescope, chains of smaller craters appear in sharp relief, spread in a diffuse ring far outside the main crater. "Each of those is bigger than [Arizona's] Meteor Crater," says Campbell. "They're secondaries made by huge blocks thrown a hundred miles and more from the impact. They don't have as much shattered material at their rims because the debris fell at a lower velocity than the initial impacting object." He also points out the bright halo around Copernicus, which reveals a different ejecta pattern in radar than in optical. "The radar image shows us the rock abundance in the ejecta blanket," he says. A landing inside Copernicus was on the schedule for Apollo 18, 19, or 20, but NASA cancelled all three missions. So the site is emblematic of unfinished business on the moon.

With radar images of the moon, geophysicist Bruce Campbell has shown the contours and resources beneath its surface.

CAROLYN RUSSO

Next up for Campbell's radar mapping? Mars. "The rover pictures [taken on the surface by Opportunity and Spirit] show geology hidden by dust and sand," he says. "So the technology that lets us look through soil on the moon will do the same for Mars. We want to use the moon science as the jumping off point for that." But the distance from Arecibo to Mars means low resolution. So he has proposed a probe with radar instruments to orbit Mars and map the surface and subsurface at 60-centimeter wavelength and with better resolution than his moon images have. The side-looking imaging radar he has suggested would reveal geologic features 15 to 25 feet beneath the surface, with a resolution measured in tens of feet per pixel, as opposed to Earth-based radar images with a mile-or-two resolution.



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The Pride of CHERRY GROVE

WITH LITTLE MORE THAN BERNARD PIETENPOL'S PLANS, ANYBODY COULD BUILD AN AIRPLANE.

BY MARSHALL LUMSDEN

Bernard H. Pietenpol (above) designed a high-wing monoplane that has inspired generations of homebuilders, including Dick Navratil (left), who owns two Pietenpols. Above left: A dataplate from a Pietenpol cockpit.

ONCE UPON A TIME IN RURAL MICHIGAN, where I grew up, people used to stop what they were doing when an airplane flew over and watch it until it was almost out of sight. Many of the flights we saw were made by Sherman Edgar, a farmer who lived in an adjacent township.

Edgar had taught himself to fly by building a tail assembly and a wing, then attaching them to a truss-shaped fuselage to make a glider. One day in the early 1930s, my dad took me to watch Edgar's friend tow him furiously across a field with a Model A Ford. After all the fuss, Edgar gained enough altitude for only a few moments of flight.

Before long, though, the glider morphed into a wood-and-fabric high-wing monoplane constructed from a set of mail-order plans and powered by a Model A Ford engine. Throughout the 1930s, on quiet summer evenings after the chores were done, we became accustomed to the sight and sound of Sherm puttering overhead. As I stood watching Edgar sail past one night in 1938, our last year on the farm, I couldn't have imagined that four years hence I would be wearing a U.S. Army Air Forces flightsuit while training to fly some of the nation's newest fighters.

Several years ago, in a hangar discussion with other pilots, I was reminded of the story of Sherman Edgar's marvelous homebuilt aircraft. "Oh yeah," somebody said, "that was a Pete 'n' Paul." Of course, he meant "Pietenpol," as in Bernard H. Pietenpol, who in 1929 designed and built the first of this type. Furthermore, I soon found out that an airplane I had thought was ancient history still existed and even thrived, like a population of rare birds nesting next to dirt and grass strips and the runways of small-town airports.

To many of the people who build and fly them, the Piet, as it is affectionately known, is an almost mystical symbol of two intrinsically American values—self-

OPPOSITE: JIM KOEPNICK; MIDDLE: GILLES AULIARD; RIGHT: COURTESY PIETENPOL FAMILY

Last year, Rob Bach (back seat) and his mother Bette flew a Pietenpol Air Camper to Blakesburg, Iowa. Pietenpol also designed a one-seat aircraft, known as the Sky Scout (above).

reliance and freedom—and a time machine back to the early days of aviation.

The Piet's story began in the hamlet of Cherry Grove, in southeast Minnesota, near Iowa. In 1919, with little more than an eighth grade education and an innate talent for mechanics, Pietenpol opened an auto repair shop in his father's barn. He soon developed a reputation for being able to fix anything, from farm equipment to motorcycles.

Along the way, he discovered airplanes. He experimented with constructing a series of biplanes by working with materials purchased from lumberyards and hardware stores, including unbleached muslin, which he used to cover the fuselage and control surfaces. Since he couldn't afford to buy an aircraft engine for his first biplane—a shaky, hardly airworthy contraption—he decided to power the aircraft with an engine from a Model T Ford automobile.

Pietenpol took a few flying lessons in a Curtiss JN-4D, the World War I-era biplane, and even bought one when they were sold off as military surplus. But he never liked it, and soon got rid of it.

The fourth aircraft that Pietenpol built was a single-place, high-wing monoplane. Chet Peek, an engineer, pilot, restorer of antique airplanes, and aviation historian, whose book *The Pietenpol Story* is the definitive history of Pietenpol's career, surmises that Pietenpol's design was inspired by the Heath Parasol, a small kitplane that was popular at the time.

By May 1929, Pietenpol had completed a second version of his high-wing monoplane, adding another cockpit. This time he had the power he wanted: In late 1927, the Model A Ford, with its 40-horsepower engine, had arrived. Pietenpol replaced the engine's heavy battery, distributor, and generator with a magneto, and the exhaust manifold with short, straight stacks. He mounted the engine backward, attaching the prop to the forward-facing flywheel, and the radiator aft, where it stuck up prominently just ahead of the front cockpit.

When the aviation editor of *Modern Mechanics and Inventions* wrote in 1929 that it was not likely that an automobile engine could be adapted for flight, Pietenpol and a friend, Don Finke, flew two of the new "two-place" machines up to Minneapolis on April 14, 1930, to prove him wrong. The editor, Westy Farmer, was won over, and the magazine printed drawings and photographs that publicized the new airplane.

The magazine dubbed the aircraft the "Air Camper," and the name stuck. A few years later, Pietenpol introduced the single-place Sky Scout, but the Air Camper has remained the overwhelming favorite of builders. *Modern Mechanics* published a set of Air Camper plans in 1932 in its annual *Flying and Glider Manual.*

Back in Cherry Grove, an 18-year-old friend of Pietenpol's, Orrin Hoopman, drafted a second set of plans for the Air Camper in 1934. Pietenpol began selling them—along with instructions on how to convert the Model A engine—for $7.50 a set. Today, builders can order the very same plans for $100 from Pietenpol's son

GILLES AULIARD (2)

Don, who says there continues to be a slow but steady demand. Additionally, the store in the Experimental Aircraft Association's museum at Oshkosh, Wisconsin, sells a reprint of the 1932 *Flying and Glider Manual* for $6.95.

Bernard Pietenpol spent the rest of his life in Cherry Grove. With the onset of World War II, the demand for Pietenpol kits and plans plummeted. Says Don: "After the war, we ran the shop for a couple of years and almost starved." His father gave up trying to make money on his aircraft designs and opened a television and radio repair shop. He continued building his own airplanes until 1970, and flew until he was 80. Pietenpol builders continued to make pilgrimages to Cherry Grove to seek his counsel.

Pietenpol died in 1984, at the age of 83. Today, his garage workshop is listed in the National Register of Historic Places. The hangar he built in Cherry Grove has been dismantled and reconstructed next to the EAA's museum, which has two of his Air Campers in its collection.

Pietenpol's legacy is an elegant little aircraft that anyone with diligence and modest skills can build with ordinary tools and readily available materials. In fact, that's the only way you can get one, unless you buy one from someone who has already done the work. For more than 80 years, people have been constructing Piets in barns, hangars, garages, basements, workshops, and living rooms—

Pilots Josef Plotnarek and Tomas Korinek spent six years building an Air Camper in the attic of Plotnarek's house in the Czech Republic. Then they had to get it down.

anywhere they could find space to lay out a jig for the fuselage framework and hang a one-piece wing. (Pietenpol built his first airplanes in an abandoned Lutheran church.)

More than 300 Pietenpols are registered with the Federal Aviation Administration. Perhaps dozens more Pietenpols are under construction. They have been built in Canada, the United Kingdom, Spain, and Brazil, and small but enthusiastic groups can be found in Australia and New Zealand. Recently a Piet was spotted in Russia.

There's no mistaking a Pietenpol Air Camper: the high parasol wing, boxy fuselage, and angular tail structures. Yet of the hundreds in existence, no two are exactly alike. Pietenpol kept making changes to the Air Camper, and he openly encouraged others to do the same. Says Don: "My dad used to say that he built the best airplane he could, and if somebody can build a better one, go ahead and do it." (Pietenpol liked improvements, but he wasn't much for frills. Somebody once said that if the Shakers had built airplanes, they would have looked like Pietenpols.)

The original plans, whether deliberately or not, seem to demand experimenting. "There are a number of places where the plans do not have certain dimensions, and there are other places where the dimensions are actually wrong,"

In the specially designed basement workshop of his New Hill, North Carolina home, Jack Phillips applied PolyTak fabric cement to his Air Camper's wing (left) before covering it with polyester sheeting. To further secure the polyester, Phillips spent 12 hours ribstitching each wing (below).

ABOVE: JAN JANULA (2); LEFT: JACK PHILLIPS (2)

DAVID BRANT

DON EMCH

BILLY MCCASKILL

says Doc Mosher, a retired corporate pilot and editor of a newsletter about the Pietenpol. "And we all find this out after a while, and then we all laugh and have a beer and say, 'Well, that's why it's called experimental.' "

Some changes, however, have gone too far, fueling the argument over what is and what isn't a true Pietenpol. "If it wasn't built from the original plans, it's not a Pietenpol," says Don.

Not considered real Air Campers: at least one biplane model, an ultralight, and a low-wing version. One major modification occurred in the late 1950s, when Ohioan John Grega decided to modernize the design by incorporating parts from the Piper J-3 Cub, including the landing gear and tail wheel. Grega powered his tweaked airplane with a Continental A65 engine. Called the GN-1 Air Camper, it has been much copied over the years (with further modifications), although some are still reluctant to welcome it into the Pietenpol flock. Don Pietenpol is adamant when he says that Grega's design "is in no way" a Pietenpol. Nevertheless, some pilots say it flies like one, and to the unschooled eye, it looks like one.

"It's fun building Pietenpols," says Ed Sampson, a retired hardware dealer in Belview, Minnesota. "It isn't hard." He should know: He's built eight Air Campers, one of which he still owns, although his health now prevents him from flying it. "Bernard told me once he'd like to build one more airplane, and all it would have in it was basic controls and an on/off switch," says Sampson. "He told me if you don't put it on there, it doesn't give you trouble. That was his philosophy."

To keep weight at a desirable 600 to 800 pounds, many builders today still forgo items such as self starters (with their heavy batteries), radios, and wheel brakes. Those who couldn't resist adding weight had to look for an engine with more power than the Ford Model A. As a result, the Air Camper has been flown with more kinds of engines—at least 30, and maybe as many as 60—than probably any other airframe in history.

Michael Cuy, an engineering technician at NASA's Glenn Research Center in Cleveland, Ohio, had just bought a half-interest in an Aeronca Champ when a friend gave him a ride in a Pietenpol. "I had never heard of a Piet before," he says. "It took me by surprise. I realized how much fun and how economical it was. We didn't have a starter, generator, electric—nothing. Just an engine and a sectional chart. I thought, Wow, I can fly wherever and whenever I want at a real reasonable price."

Cuy and his fellow owner sold their Aeronca, and he ordered plans from Don Pietenpol. He chose a Continental A65 engine over the Model A because the extra power would enable him to carry passengers. "I never totaled up my bills, but

COURTESY FRANK PAVLIGA

Ben Taylor flies the Antique Air Association's Air Camper (below). Right: In 1989, a flock of Pietenpols landed at the annual fly-in at Brodhead, Wisconsin, to celebrate the 60th anniversary of the first Pietenpol flight.

MIKE GRETZ

MARSHALL LUMSDEN

Like snowflakes, no two Pietenpols are exactly alike. Engines are assorted, and cowlings range in shape from rectangular to oval to round. Below: Pietenpol builders Larry Williams (right) and Douwe Blumberg talk shop in Oshkosh, Wisconsin. Williams' yellow Piet is powered by a Ford Model A engine.

I'm guessing it cost about $13,000," he says. "But if you're a good scrounger and you get some used parts, I think you can do it for seven thousand."

If there is such a thing as a deluxe Air Camper, Dick Navratil from Arden Hills, Minnesota, has one. He first saw a Pietenpol in the 1970s at Oshkosh. Says Navratil: "It was the most beautiful airplane I had ever seen, and I decided then and there that someday I was going to have one." When he finally got around to building one, it took him four years and three months. Like others, he looked for a way to save money, and one was to use house paint to cover the Piet. "The Sherwin-Williams paint has UV protection in it, and the latex is flexible so it doesn't crack," he says. He also added brakes, a tail wheel, and a 12-volt battery, bringing the craft's weight to nearly 700 pounds. But he began to think of ways he could build a better one.

Then he saw a Rotec radial engine. Manufactured in Australia, the model he wanted generated 110 horsepower—and a nice throaty sound. "I wanted something that nobody else has," he says. At 810 pounds empty, Navratil's second Piet is a heavy one, but "the power response is incredible," says Navratil. "On both my Piets, the controls are extremely responsive, but I think the additional weight of the new one gives it more stability. I think Bernard Pietenpol would be doing this himself if he were still around."

Despite being widely scattered and working almost entirely in isolation, Piet builders and fliers are closely bound. Matt Dralle maintains an online forum for Pietenpol builders to post problems and get solutions (*www.matronics.com/list-browse/pietenpol-list*). The quarterly *Brodhead Pietenpol Association Newsletter* shares news, photographs, building tips, and advice from experts and advertises parts and fully or partially completed Piets for sale. Says editor Doc Mosher: "You can't buy a kit, so you have to go to the lumberyard and buy the lumber, saw it up, plane it and glue it, and make your airplane. And every one is different."

What you have after all those hours of lonely shop work is a little wood airplane

MICHAEL D. CUY

that cannot be said, in the words of poet John Gillespie Magee Jr., to "have slipped the surly bonds of earth" and go "where never lark, or even eagle, flew." The Pietenpol motto is "Low and Slow Since 1929." Flying in Piets is a noisy experience, and the snug cockpits, with their hard wood seats, leave occupants exposed to the weather. Cruise speeds are somewhere between 70 and 80 mph, and the airplanes with the smaller engines are laborious climbers. So why build one?

"It's just really a lot of fun," says Navratil. "When I was flying my company's Piper Seneca for business, I'd flip on the autopilot and take it up to 15,000 feet and never touch the controls. I'd do whatever the controller tells me to do. In the Piet, I'm most commonly hardly more than 500 feet: Down there you can smell the farms and you can putter around and wave at people on the ground."

THE PLACE TO GET TOGETHER with other Piet builders and owners is the airport at Brodhead, Wisconsin, in the rolling green landscape of the south-central part of the state. Every summer since 1975, the airport has been hosting an annual fly-in. It seems an appropriate meeting place for an aero club in love with a 1929 homebuilt. Its two broad turf runways are bordered by a two-lane road and fields of tall corn, with a fringe of trees on one side.

Most of the aircraft at the fly-ins are from Wisconsin and neighboring states in the Midwest. In 2007, when I was there, 21 Piets were visiting, more than average. Among them was an Air Camper from Quebec; the French-Canadian pilot had never seen another Piet until he landed at Brodhead.

The Pietenpol, with its short range and slow speed, is not a comfortable airplane for long-distance flights. In 1993, though, M.T. "Sparky" Sparks and his stepson Scott Liefeld stuffed their gear into the front cockpits of two Air Campers and took off from Gillespie Field in San Diego, California, for Brodhead. It was a 15-day journey, during which they stopped for fuel 46 times.

More people drive to Brodhead than fly. The land around the airfield is open to campers, and the scene has the feel of a country fair. There is Doc Mosher and wife Dee at the table, ready to sign you in and give you a handout outlining the day's forums, which are hosted by Pietenpol experts. Mosher and his wife also remind you to get tickets for Saturday night's traditional grilled pork chop dinner. Soft drinks from the cooler are 75 cents, paid for on the honor system. People mill around the parked airplanes, talk to the owners, and admire the exquisite handiwork that can go into a Pietenpol.

Hang around the airplanes long enough and somebody will offer to take you for a ride. Pete Smith, from Lake City, Michigan, asked me if I wanted to go, and I accepted immediately. Getting into the front cockpit isn't easy: You have to squirm between the struts and wires without whacking your head. It takes precise instructions from the pilot every step of the way.

MICHAEL D. CUY

After a quick liftoff and gentle climbout, we level off at 500 to 600 feet and cruise above farmland at a leisurely 75 mph. The Piet feels stable and predictable. The visibility is spectacular, especially since you can look over the side of the fuselage almost straight down. I observe things that I never seem to notice while flying in other airplanes: birds, people and cars on the ground, and swirling patterns made by breeze-swept corn tassels.

When I was a kid, I sometimes got invited to go for a ride in a Ford roadster with the top down. My flight in the Piet reminds me of those rides—that feeling of gleeful release.

Visit the Web site for more stories and a Pietenpol family album.

For his second Pietenpol, Dick Navratil (above) wanted the look of fine wood. He covered the fuselage with thin plywood, which he masked with fiberglass and four coats of varnish. Left: More than 20 Pietenpols turned up at the 2009 AirVenture at Oshkosh, 80 years after the little airplane was designed.

REMINDERS OF PIETENPOL HISTORY are plentiful. You can still find people who knew and worked with Bernard Pietenpol, and some of the airplanes he built still exist. His earliest surviving Air Camper, N12937, first flew on April 20, 1933. It survived five owners, two serious crashes, several restorations, and several thousand flying hours. Today it is displayed at the EAA museum.

Don Pietenpol lived the history. As far as he can remember, airplanes were always around. When he was three, he took his first ride in an Air Camper, which had no seatbelts. "My dad took the belt off his pants and strapped me in the front cockpit," he recalls. Bernard taught him to fly when he was nine, and he got his pilot's license at 16. Don was a U.S. Air Force pilot before working as an engineer at IBM in nearby Rochester, Minnesota, where he still lives.

Bill Knight, who lives in Brodhead, owns the last Air Camper Pietenpol ever built. It was finished in 1969. Still flyable, it is powered by a Chevy Corvair engine. When Pietenpol's grandson put it up for sale, Knight bought it because, he says, he didn't want it to go to a museum. "I thought it should be available where people could see how Bernie himself built an airplane," says Knight, who frequently shows off his Air Camper at vintage-airplane fly-ins around the country.

Modern Piet builders are acutely aware of the cherished tradition begun in a far corner of Minnesota 81 years ago. Oscar Zuniga, an engineer and Pietenpol owner in San Antonio, Texas, says: "If you're looking for a 'Insert Tab A into Slot B' type of manual, you won't find it. That's the beauty of it. It's like sitting down at your dining room table and emptying out all the pieces of a big, beautiful jigsaw puzzle of Cherry Grove, Minnesota, and then just sorting it out bit by bit. I work on a new and interesting part every day until I just can't seem to make any progress there, then I work on another area for a while.

"Building a Piet is the same way," he says. "And with this jigsaw puzzle, you'll find a little bit of Mr. Pietenpol's airplane and barn in every piece."

JIM KOEPNICK

Pack Man

CHARLES BROADWICK INVENTED A NEW WAY OF FALLING.

BY LISA RITTER

PARACHUTE DESIGNS have been around since the 15th century, but in the 1880s, they were still a rare sight, so it's hard to say what inspired 10-year-old John Murray, a poor boy in Grand Rapids, Michigan, to design his own parachute. According to a later account in the *San Francisco Examiner*, the boy took "a piece of tissue paper, some twine, and an exceedingly disgruntled cat, undesired in the neighborhood" and fashioned a parachute, then dropped the surly aeronaut off a high bridge. As the tissue canopy filled with air and the parachute glided off for half a mile, the boy could see his future.

At 13, Murray made his first ascent with a hot-air balloon. He planned to ride the balloon down as the air cooled. But once in the sky, he found the balloon was ablaze, most likely due to a spark from the wood fire that supplied the hot air. The boy climbed up the balloon and used his coat and a sand bag to put the fire out. He landed unharmed, but the close call must have reinforced his respect for a dedicated method that would bring someone down safely from a great height.

By age 16, he had taken the stage name Charles Broadwick, and was performing in venues like fairs and resorts, and entertaining crowds with an act in which he would ascend with a balloon and float back down with a parachute.

The preparation was as much a part of the show as the ascent and drop. A

Stashing the parachute in a backpack, Broadwick saved future jumpers from injury or death. Three Broadwick packs survive today; one (opposite) is stored at the National Air and Space Museum.

crowd watched as the 90-foot-high balloon, filled with hot smoke, fought to rise. A dozen or more strong men held down its tethers. Meanwhile, Broadwick inspected his parachute rig, stretched on the ground. The apparatus was simple, and weighed about 40 to 45 pounds. The canopy was made of heavy muslin strips that were stitched together lengthwise to form a dome.

The rim of the dome was connected by suspension lines to a trapeze, which the parachutist would grasp. The limp canopy was suspended from the bottom of the balloon by a rope, which ran through a mechanism with a blade embedded in it. When the aeronaut was ready to cut the parachute free, he would tug on a long cord attached to the blade, severing the rope and releasing the parachute from the balloon.

Once the parachute was inspected and the balloon filled, Broadwick would duck into his nearby tent and don his spangled tights. He would then ring a loud bell, dash out to the balloon-and-chute rig, grasp the trapeze bar, and shout, "Let go!" The men released the ropes and the balloon shot up, with Broadwick running briefly until the balloon pulled the parachute and him aloft. Upon reaching a height sufficient to ensure the parachute would fill with air as it dropped, Broadwick would cut himself and his parachute free.

Relieved of its weight, the balloon would twist over, belching out black smoke, and fall to the ground. Briefly, Broadwick would plummet—eliciting gasps from the pompadoured ladies and bowler-hatted men. But as the chute filled with air, his speed would slow, and the canopy would waft him—usually gently—to the ground.

Although aeronauts ballyhooed the risks, sometimes parachuting from a hot-air balloon really was "death-defying." In fact, in 1905, Broadwick watched his beautiful companion, known as Maude Broadwick, fall to her death after getting caught up in the balloon's tethers. Another common danger was ascending in a closed area. The aeronaut—suspended 30 or 40 feet beneath the balloon—could be slammed against nearby buildings or trees, and seriously injured or killed.

In 1906, Broadwick demonstrated an ingenious solution he had devised to protect the parachutist from such dangers. He simply folded the canopy and its suspension lines into a pack, which he then strapped to his back. Broadwick ascended while tethered directly to the balloon—just 12 feet below it, rather than 40.

Jumping in San Diego in 1914, Broadwick hoped to persuade the U.S. Army to adopt his "coatpack" for military aviators' safety.

What deployed the parachute was a lightweight cord called a static line. One end of this line was attached to the balloon, and the other to the peak of the parachute canopy. As the jumper left the balloon, his weight would pull the static line taut, and yank the parachute from the pack. The line would then snap, and the canopy, filled with air, would float the aeronaut to earth.

BROADWICK TOOK PRIDE in his craft, but money was always the master. Aeronauts, like other entertainers, continually sought fresh additions to their acts: lions, monkeys, explosives, one-armed men. Broadwick was about to discover a perfect drawing card: a spitfire of a young woman named Tiny.

In the spring of 1908, Broadwick was performing with the Johnny J. Jones Exposition Shows, touring the South. Georgia "Tiny" Jacobs, 15, a deserted wife with a baby daughter, had hitched a ride with friends to see Jones' carnival in nearby Raleigh, North Carolina. Due to a farmers' strike, Tiny was on hiatus from her grueling cotton mill job. Watching Broadwick's spectacular show, she resolved: "That's what I want to do." While the rest of the crowd ran off to witness his landing, Tiny waited for Broadwick to return to the launching grounds. She desperately wanted to be an aeronaut. The story goes that Broadwick needed convincing, but after he got her mother's permission and in turn promised to send money back for the baby, he added the young woman to the troupe.

As the Jones shows continued to tour the South, "Tiny Broadwick" became an instant headliner. Just under five feet tall and dressed in a ruffled dress, bloomers, and bonnet, "the Doll Girl" was usually described as younger than she was, and almost always referred to as Broadwick's daughter. (Interestingly, she was sometimes referred to as his wife. Even a member of Tiny's family is unclear on what the relationship was.)

As Charles and Tiny plied their balloon-and-chute trade on the carnival circuit, aviation advanced

OPPOSITE: ERIC LONG; RIGHT: SAN DIEGO HISTORICAL SOCIETY

Petite jumper Tiny Broadwick got her boss the press attention and the public excitement that eventually caught the eye of...

rapidly: Smoke balloons became antiquated; dirigibles, passé. The aeroplane had arrived. In 1912, on a field south of downtown Los Angeles, crates full of engines, bamboo frames, and white canvas wings were being pried open, and the parts assembled into monoplanes and biplanes for the third Dominguez Air Meet, which newspapers anticipated would be the greatest aviation event yet held in the United States. Attendees would include the most famous members of the flying world: airplane designer Glenn Curtiss, future manufacturer Glenn Martin, pilot Lincoln Beachey. Also in attendance would be Charles Broadwick and Tiny, who had moved west the year before.

On opening day, Tiny ascended with a hot-air balloon and did a double parachute drop, descending partway with one parachute, then cutting away from it, opening a second, and completing her descent. Glenn Curtiss expressed disapproval of parachuting, telling a reporter that he instructed his pupils to never jump in the event of an emergency: "It's much safer for an operator to remain in his seat." Phil "Skyman" Parmelee added: "None of that parachute jumping for us aviators," he told the *Los Angeles Times*; "it's too dangerous." (A few months later, Parmelee's biplane would flip in high winds, and he would die at age 25.) These sentiments were not surprising. At the time, no one had attempted to jump from an airplane. (The first such jump would be made two months later, when Albert Berry leapt from Tony Jannus' flimsy Benoist 1,500 feet over St. Louis, Missouri.)

At the Dominguez Field meet, shrewd businessman Glenn Martin took notice of Broadwick's "coatpack" parachute—with media darling Tiny as its demonstrator. The following year, Martin garnered headlines and world records for Tiny. In June 1913, he dropped Tiny from his biplane over Griffith Park in Los Angeles, and two months later, he dropped her from a hydroplane over Lake Michigan. Wearing Broadwick's coatpack, she became the first woman to parachute from an airplane, and the first person to parachute from a hydroplane.

Martin and Broadwick apparently reached a curious agreement about the coatpack. Accounts vary, but newspapers repeatedly report that the device had been invented by Martin. A 1914 *Los Angeles Times* article about "Martin's Life-Vest" says: "Although the life vest is...[Martin's] own invention, the actual construction was done by Charles Broadwick, an old balloonist, under Martin's direction." Broadwick seemed to acquiesce, telling the *San Diego Union* in 1914: "I have spent many years of my life, giving up my time and pleasure to help Mr. Martin develop the parachute to the stage where we have it today."

At most, Martin took Broadwick's design and slightly tweaked it for suitability to the airplane. Taking credit for the invention of the packed parachute was shameless, but Martin went further: In March 1914, he applied for a patent for Broadwick's device.

Over the years Martin held to his claim. A 1946 Martin Company newsletter gushed that he had invented the packed parachute and—oddly—the "first free-fall parachute." In a 1927 deposition, Broadwick finally took credit, saying, "It was my own invention" and that Martin's claim was "simply an advertising matter." Tiny later verified this, telling an interviewer for the Columbia University Oral History Department that when they all first met, Martin "knew nothing about parachutes."

But Broadwick apparently did not let the Martin arrangement sour him. Still cutting a handsome figure, he entertained the West Coast ladies. He was a real "sheik," Tiny reminisced years later in *Getting off the Ground* by George Vecsey and George C. Dade, a book about pioneer aeronauts. "He was a fine-looking man. He'd go out and pick out the best-looking women and take 'em out to dinner. That was his excitement, aside from working with the [parachutes]. I've seen him

...aviation businessman Glenn Martin (right, standing). By 1913 Martin was taking credit for Broadwick's invention, and the following year he patented it. Here, he and Tiny watch Broadwick stitch up the canopy of a parachute.

TOP: NASM (SI 2003-12302); BOTTOM: LIBRARY OF CONGRESS

take four beautiful women into the Ship's Café, down in Venice." As for Tiny, she had married a young seaman in 1912.

AS THE GREAT WAR loomed in Europe, Broadwick offered a nobler use for his coatpack.

At about nine pounds, the pack was now lighter, smaller, and better suited to snug cockpits. In a series of demonstrations between early 1914 and early 1915 at North Island in San Diego, Charles and Tiny wowed pilots, generals, Congressmen, and reporters with this "life preserver of the air," as it came to be called.

At first, the idea of using the device to save airmen's lives received consistent, albeit faint, praise. The Army even purchased two Broadwick packs for further testing—but they ended up on a shelf until after the war.

Pilots weren't eager to adopt a parachute either. They argued that carrying one showed a lack of trust in one's machine and in one's flying ability. Army brass arguments wavered between two conflicting fears: that the presence of parachutes would make pilots abandon their machines needlessly, and that current parachutes weren't reliable enough in all situations.

True, the static-line parachute was not ideal for all cases of airplane failure. If the craft were plummeting, the parachutist tethered to it could never break free. But that was no reason for wholesale rejection of the device. In 1916, another parachute showman-turned-inventor, Leo Stevens, had offered the Army his pack, which featured a ripcord that the jumper could pull to deploy the chute, ensuring the pilot could free himself from a falling airplane. But the Army, deeming it "dangerous" for inexperienced jumpers, turned it down as well.

In those days, fires in airplanes were common—so common that, in fear of a fiery end, some pilots carried pistols to commit suicide; others chose to jump to a quick death. If a pilot had Broadwick's static-line parachute, however, he might have a chance at escaping a burning airplane.

SAN DIEGO HISTORICAL SOCIETY

After Broadwick's San Diego jump from a Martin T Tractor biplane, the Army was interested in the coatpack, but decided against buying it for World War I aviators.

What finally convinced the Allies of the utility of carrying parachutes in airplanes? The enemy. German aircraft had primitive static-line-operated packs, and when the airplanes caught fire, the pilots jumped out and parachuted safely to the ground. Seeing the benefits first-hand, Allied pilots came around, but the brass continued to hesitate. By the time they came around as well, the war was over.

Broadwick's coatpack did figure prominently in the development of the parachute immediately after World War I. A group of civilians under the direction of Major E.L. Hoffman gathered all the parachute models they could get their hands on and set out to find the perfect compromise. Former Broadwick protégé Leslie Irvin was a key player, as was another former California acquaintance, Floyd Smith. In the end, the group took three elements—Broadwick's coatpack, Stevens'

ripcord, and a pilot chute (a small canopy that opens to draw out the main canopy)—and created Airplane Parachute Type-A. Successfully tested by Irvin, the parachute was put into production. Irvin chutes saved countless lives, including that of young airmail pilot Charles Lindbergh.

By this time, Broadwick, who had parted ways with Tiny and remained in California throughout the war, had found love again. A young would-be actress who enjoyed the thrill of the air, Ethel Knutsen married the much older Broadwick and began jumping from airplanes.

On February 12, 1920, Ethel was testing one of her husband's new parachutes over San Francisco. As a movie camera in another airplane recorded the scene, the suspension lines of Ethel's parachute tangled, and she plummeted 2,000 feet to Marina Aviation Field. She died hours later.

Following Ethel's death, Broadwick seemed to age dramatically. Years of broken bones, the deaths of his beloved Maude and Ethel—the misfortunes had taken a toll.

Broadwick in 1915, around the time of more demonstration jumps for the Army.

Photographs show a changed man.

In the late 1920s, Broadwick made national headlines when pilot "Mickey" McKeon tested two of the inventor's patented "planechutes," designed to bring down a disabled or fog-enveloped aircraft. The tests were only partly successful. Broadwick continued to tinker in his San Francisco workshop, but by 1940 he was officially retired.

In 1942, he was admitted to the hospital, and the following year he died of heart disease. He did not die a rich man, or a celebrated one, and he seems to have died alone—family ties long broken, no pretty young companion by his side.

Forgotten for decades, Tiny found renewed fame in old age. In 1964, she donated an original Broadwick coatpack to the Smithsonian Institution. Due to its fragile condition, it is now kept in a climate-controlled storage unit in Suitland, Maryland. The other two existing coatpacks reside in North Carolina: one at the state's Museum of History in Raleigh, the other with Tiny's family. Credited with more than 1,100 jumps, Tiny died in 1978.

Broadwick adjusts the fit of a coatpack on an unidentified aviator. His simple and ingenious invention continues to assist parachutists today; virtually all parachutes are now stowed in packs that are strapped to the jumpers' backs.

How are Broadwick's contributions remembered today? Peter Hearn, author of five books on parachuting history, describes Broadwick as "one of those leading pioneers who used practical experience and technical expertise, rather than scientific qualification, to advance the development of a life-saving parachute." Hearn also believes Broadwick deserves some credit for pioneering static-line chute deployment.

The U.S. Parachute Association's executive director, Ed Scott, says that "just about all modern parachute systems" retain Broadwick's chief innovation: "an integrated, form-fitting harness and container system nestled on the back." Static-line deployment is still used by some novices making their first jumps, to ensure that the chute will open, but experienced parachutists today deploy a folded pilot chute that inflates and then extracts the main canopy.

As for the written record, Tiny has been memorialized in numerous books and magazines, but Charles' name is fading. You'll see a few parachute patents citing a Broadwick design, and aviation histories will briefly mention his invention of the backpack parachute. But what you won't find in any of those documents is the complex tale of the man who spent a lifetime perfecting a life preserver of the air.

TOP: SI-90-2210-AM; BOTTOM: SAN DIEGO HISTORICAL SOCIETY

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PICTURES WORTH A SECOND LOOK

WHEN PHOTOGRAPHERS ask for a vertical shot, they don't mean this. The 70–200mm telephoto lens that Mike Shore of Austin, Texas, used to grab this Douglas DC-3D created a compression effect, "in which the subject appears a little more extreme in comparison to the background," he says. "This is all in the glass, and it's a great technique to capture the eye." The airplane landed in Bend, Oregon, around sunset on January 14, 2007. Shore asked to make an air-to-air shot, and owner Jonathan Phelps agreed. Helicopter pilot Sharon Vickers took Shore to 1,500 feet in a Robinson R44, where he set his Canon 20D at 1/125th of a second, f/3.2, and ISO 800. "It was really dark out," he says. Pilots Steve Dunn and Paul Bazeley flew the airplane about 15 to 20 feet off the runway at almost full speed, about 140 knots, then performed a two-G, 40-degree pullup. Shore made the photo as the Pratt & Whitney R-1830-94 Twin Wasp radial engines, each with 1,350 horsepower, clawed their way to a thousand feet, at which point the pilots banked right at about 100 knots. "At low altitude and low speed, safety is power," says Dunn, who was in the left seat. "Always leave yourself a way out." The finely restored DC-3—"You could eat off her, anywhere on the airplane," says Dunn—will join a flyover of 25 to 30 DC-3s at the AirVenture gathering in Oshkosh, Wisconsin, this summer (see p. 27).

The Man Behind the Miracle on the Hudson

In his autobiography, Captain Chesley Sullenberger explains why he was the right man for the job on that historic day.

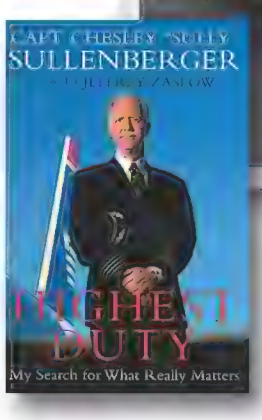
Highest Duty: My Search for What Really Matters

by Chesley Sullenberger with Jeffrey Zaslow. William Morrow, 2009. 340 pp., $25.99.

CHESLEY SULLENBERGER, the US Airways pilot who ditched his Airbus A320 in the Hudson River on January 15, 2009, is the most famous aviator since Chuck Yeager, who was deified by Tom Wolfe in the 1979 book *The Right Stuff.* Yet unlike Yeager, a war hero, brash test pilot, and media darling, Sullenberger had toiled in obscurity—a phrase he himself uses in this eminently readable book—as an unremarkable airline pilot for a pinch-penny airline, flying prosaic domestic routes after a routine, warless U.S. Air Force career flying F-4 Phantoms. Sullenberger had a tough cross-country commute, two daughters who weren't happy when he was away from home, and financial problems—an airline salary cut by 40 percent, union bitterness, a real estate investment going bad—so he approached life guardedly.

You can imagine his face clouding just a bit when he writes about an Air Force buddy who was a hotdog: nice guy, good pilot, but not Sully's style. Even in the portrait on the book's cover, he is *frowning,* for Pete's sake.

Yet all of this prepared him for his day in the sun. Sullenberger will be the first to tell you that he's no hero—that a hero is the person who volunteers to run into the burning building, while he was the guy on the top floor of the building who had to figure out an escape. That's not heroism—that's coolness, capability, focus.



The author prepares to board a T-33 as a freshman at the U.S. Air Force Academy.

Though this book isn't written for an aviation-besotted audience, there's plenty of flying in its pages, and it's an interesting look into the cockpit—and mind—of a seriously competent airline captain not too proud to practice good CRM (crew resource management). I can think of four airline-captain friends—two retired, another flying corporate, and a fourth still flying the line—and I'm confident they'd all have done pretty much what Sullenberger did. Airline flying has long attracted so many of those cool, capable, and focused individuals, and in fact Sullenberger wonders how long that will continue, what with the cheapening of the job both literally and figuratively.

Jeffrey Zaslow, Sullenberger's co-author, deserves enormous credit for helping to tell the pilot's story entertainingly and movingly while preserving a full measure of Sullenberger's stern personality.

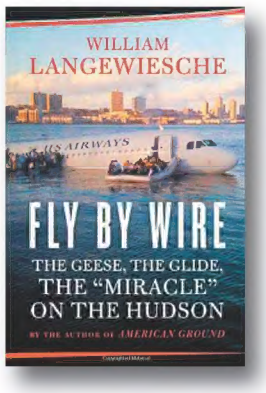
STEPHAN WILKINSON IS THE AUTHOR OF *THE GOLD-PLATED PORSCHE.*

COURTESY CHESLEY SULLENBERGER

Fly by Wire: The Geese, the Glide, the "Miracle" on the Hudson

by William Langewiesche. Farrar, Straus and Giroux, 2009. 208 pp., $24.

WILLIAM LANGEWIESCHE is a smart and skillful journalist. He is also a pilot, alert to the nuances of the successful Hudson River ditching of the US Airways Airbus A320 whose engines had been disabled by bird strikes. Not easily snowed, he begins by recounting the empty pomposities of a National Transportation Safety Board hearing with just the right tone of exasperated cynicism. His meticulous account of events preceding the flight—most of which had nothing to do with it—builds suspense in a police-procedural sort of way. He digresses amusingly upon the internecine relations of airplanes and birds. He then resumes his narrative, only to abandon the crippled A320 in mid-glide for a 54-page cadenza on the subject of fly-by-wire (FBW) control systems. He sees these largely through the eyes of Bernard Ziegler, an especially engaging, quirky, and charming Airbus engineer, test pilot, and FBW advocate. Finally, we rejoin Captain Sullenberger and his A320 as they proceed to their wet but happy ending.



And after closing this slender volume we may wonder: What did fly-by-wire have to do with the Hudson ditching?

In a modern FBW airplane, a computer flies the airplane. The computer receives its instructions from the pilot's stick and rudder pedals. Most of the time the computer is invisible, but it stands ready to prevent certain egregious piloting blunders. But FBW had no bearing on the Hudson incident. The A320's FBW software makes no special provision for a ditching, which from a piloting standpoint is little different from a runway landing. There is no evidence that in the same hands a non-FBW airplane would have fared any differently. Smooth water and a fortunate lack of river traffic mattered; FBW didn't.

Fly-by-wire is an interesting and controversial subject, but Langewiesche's account of its history and politics has more Bernard Ziegler charm than thorough analysis and balanced reflection. Two accidents that Langewiesche discusses in detail, one involving a hotdogging Airbus pilot trying to impress—a reliably fatal ingredient in aviation—and the other a befuddled crew in a non-FBW Boeing 757 in the Andes, shed little light on the subtleties of FBW and the causes of airline accidents. Last year's Air France 447 crash, on the other hand, did grimly illuminate the difficulty of programming flying automata to cope with every eventuality, but

Reviews & Previews

Langewiesche passes over that accident lightly. Neither pilots nor computers are perfect, but Langewiesche, with Ziegler, concludes that pilots are statistically the more deadly of the two. However, we have yet to discover all the fresh possibilities the marriage of the two may engender.

Despite its lack of coherence, this is an entertaining and instructive book.

PETER GARRISON IS A FREQUENT CONTRIBUTOR.

Credits

An Extra Two Seconds. Bob White retired from the U.S. Air Force as a major general in 1981. Al Hallonquist has studied aerospace history since high school, when he learned to fly.

It Started Off Bad and Went Downhill. William Onderdonk flew anti-submarine aircraft out of Chincoteague, Virginia.

Simply the Best. When Debbie Gary is not flying, she writes from her home in a Texas airpark.

How Things Work: Missile Killer. Damond Benningfield is a science and technology writer in Austin, Texas.

Grab the Airplane and Go. Frequent contributor Stephen Joiner writes about aviation from his home in southern California.

Osprey at War. Writer and photographer Ed Darack, *www.darack.com*, frequently covers U.S. Marine combat operations.

Mr. Fix-It. Robert Zimmerman's latest book is *The Universe in a Mirror: The Saga of the Hubble Space Telescope and the Visionaries Who Built It* (Princeton, 2008).

How Good Is Your Airline? Craig Mellow is a New York-based writer.

What Lies Beneath. Michael Klesius is an *Air & Space/Smithsonian* associate editor.

The Pride of Cherry Grove. Marshall Lumsden is a former World War II fighter pilot.

Pack Man. Lisa Ritter became interested in Charles Broadwick when she discovered that he boarded with her great, great aunt in San Francisco in the 1920s. She is currently writing a book about him.

Forecast

IN THE WINGS AND ON THE WEB...

IN THE NEXT ISSUE

The Last Gunslinger
Are dogfights obsolete? Not if you're the pilot of an F-15C.

Fooling Mother Nature
Cautionary Tale: Scientists in the 1940s discovered that hurricanes don't like to be messed with.

Full House
Now that the space station has been built, how will it be used?

Big
The restoration of a Convair B-36 Peacemaker.

The Long Goodbye
How 30 years changed the space shuttle.

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ILLUSTRATIONS: HARRY WHITVER

Old Faithful

IN MAY 1985, a Boeing 767 operated by Trans World Airlines became the first twin-engine airliner allowed to fly directly from St. Louis, Missouri, TWA's hub, to Frankfurt, Germany, without altering its course to comply with an international requirement that it never be more than an hour's flying time from an airport where it could land. The rule harkens back to the days of piston engines, which were so unreliable that at least four were considered necessary for a long flight over the ocean or hostile terrain. Even with four engines, airliners sometimes had to ditch—most notably the Boeing 377 Stratocruiser, three of which had engine and propeller problems that forced them to land in the water.

With the arrival of turbojet propulsion on the de Havilland Comet and Boeing 707, both of which had four engines, the airlines began to build a record of engine reliability that is now nearly perfect. Engineers could calculate the odds that more than one engine might have to be shut down in flight, and determined that with three engines, that possibility was so remote as to be virtually nonexistent. In 1964, all three-engine jets were exempted from any sort of time rule, and the International Civil Aviation Organization expanded the rule for twin-engine jets from 60 minutes to 90. Engines are rated by dispatch reliability—a measurement of how many flights are delayed or cancelled because of engine problems—and today, it is not unusual for an engine to have a rating in excess of 99.9 percent.

As reliable as jet engines are, they are also expensive to buy, operate, and maintain. It's no coincidence that the Airbus A300 and the Boeing 757 and 767, all long-distance designs, have twin engines. Boeing's big 777 is

TOM MILLER

The turbojet engine grew so reliable that passengers can now fly direct routes across the globe.

powered by two GE90s, the largest turbofan ever to fly. Out of the experience with the first generation of twins emerged a consensus among regulators that if a twin-engine jetliner had certain redundant equipment on board, a trained crew, and a proving period of, say, a year, it would be able to operate safely up to 120 minutes from an airport. The stipulations form a rule known as Extended-(range) Twin-(engine) Operational Performance Standards, which became crunched into the acronym ETOPS. In its earliest form, the rule was aimed at transatlantic routes that forced airlines to fly doglegs to stay within an hour's flight on the remaining engine to diversion airports in Iceland or Greenland. Still, regulators wanted 12 to 24 months of proof of reliability before granting further extensions.

With the 777, Boeing pressed the Federal Aviation Administration to approve the airplane-engine combination, together with its list of redundant equipment such as fire extinguishing systems and electrical generators, for ETOPS up to 180 minutes on the day it was delivered. European regulators balked at the "ETOPS out of the box" policy, so European operators had a 120-minute limit for one year at delivery, and after the trial period, they could apply for a 180-minute limit. Today, with some exceptions for weather conditions in the polar regions and the vast Pacific Ocean, airlines can use their twin-engine fleets to fly direct routes between almost any two cities on the planet, saving time and fuel while delivering passengers safely to their destinations.

GEORGE C. LARSON, MEMBER, NAA